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Estimating Quantities of Materials for Concrete

Aggregate Engineer Presents Method of Computation Based on Past Research that Should Give Correct Proportions of Cement, Aggregate and Water for the Batch — a Graphical Solution Chart Based on the Same Formulas Is Presented

By STANTON WALKER

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THERE have been several interesting methods advanced during the past few years by which the concretor may readily figure out the right proportions for a batch when a certain mix or a certain strength is called for by the specifications. Here is a method that is based on past research and takes into consideration the ratio of water to cement, relative consistency, sizes of aggregates, fineness modulus, and the unit weight of the aggregates. Coming as it does from a recognized authority on proportioning, it represents a combination of theory and practice based on sound considerations. The chart included in the article presents a visual method of solution that checks closely with the results of the slower method of mathematical solution described in detail by the author as well as with actual field tests. This appears to be a worthwhile contribution to the science of making good concrete economically.—The Editors.

SINCE concrete became an important structural material there has been a demand for an accurate method of estimating the quantities of materials which it requires for different proportions. Various formulas have been proposed and a number of different tables have been computed to assist the engineer in estimating the quantities of cement and aggregate for concrete. Many of such formulas and tables lack flexibility or accuracy, or both, due to the efforts made to attain simplicity. The formulas for the most part are based on the voids or density of the aggregate; but do not take into account the important part played by the quantity of mixing water in determining the volume of concrete. For example, a comparatively fine aggregate with high voids may produce a greater volume of concrete for the same amount of cement than a coarser aggregate with low voids, due to the fact that more mixing water is required for the finer aggregate than for the coarser material. A method for the estimation of quantities of materials based on the density of the aggregate, which takes into account the quantity of the mixing water, is fundamentally correct.

The method described in this paper is based on the obvious fact that the volume of concrete is equal to the volume of the solids in the aggregate plus the volume of cement paste, so long as there is a negligible quantity of unfilled voids or entrained air. No particular originality is claimed for the method, although so far as we know it has not previously been advanced in this form or in one so practical of application and at the same time productive of accurate results. Talbot and Richart, in Bulletin No. 137 of the University of Illinois Engineering Experiment Station, describe a somewhat similar method based on the solids of the coarse aggregate, and the volume of the mortar as determined from the "mortar-voids" test. The method described in this article eliminates the "mortar-voids" test and seems to give equally accurate results. See Table 4.

The following simple formula is derived, from which the barrels of cement per cubic yard of concrete may be calculated if the concrete is plastic and workable, and the approximate water-ratio, the weights of aggregates used with each 94 lb. of cement, and the approximate specific gravities of the aggregates are known:

$$\left.\begin{array}{l}\text{Bbls. of cement per}\\ \text{cu. yd. of concrete}\end{array}\right\} = \frac{6.75}{0.5 + x + \dfrac{Wf}{62.5\,Sf} + \dfrac{Wc}{62.5\,Sc}} \quad (1)$$

Where:

x = water-ratio; ratio of volume of mixing water to volume of cement.

Wf = weight of fine aggregate in pounds used with one 94 lb. cu. ft. of cement.

Wc = weight of coarse aggregate in pounds used with one 94 lb. cu. ft. of cement.

Sf and Sc = apparent specific gravities of fine and coarse aggregates, respectively.

For aggregates of average specific gravity this equation can be reduced to the following simple form:

$$\left.\begin{array}{l}\text{Bbls. of cement per}\\ \text{cu. yd. of concrete}\end{array}\right\} = \frac{6.75}{0.5 + x + \dfrac{(Wf + Wc)}{166.6}} \quad \text{———}(2)$$

The solution of Equation 2 is made easy by the chart in Figure 1.

Derivation of Equations

The method may be expressed algebraically as follows:

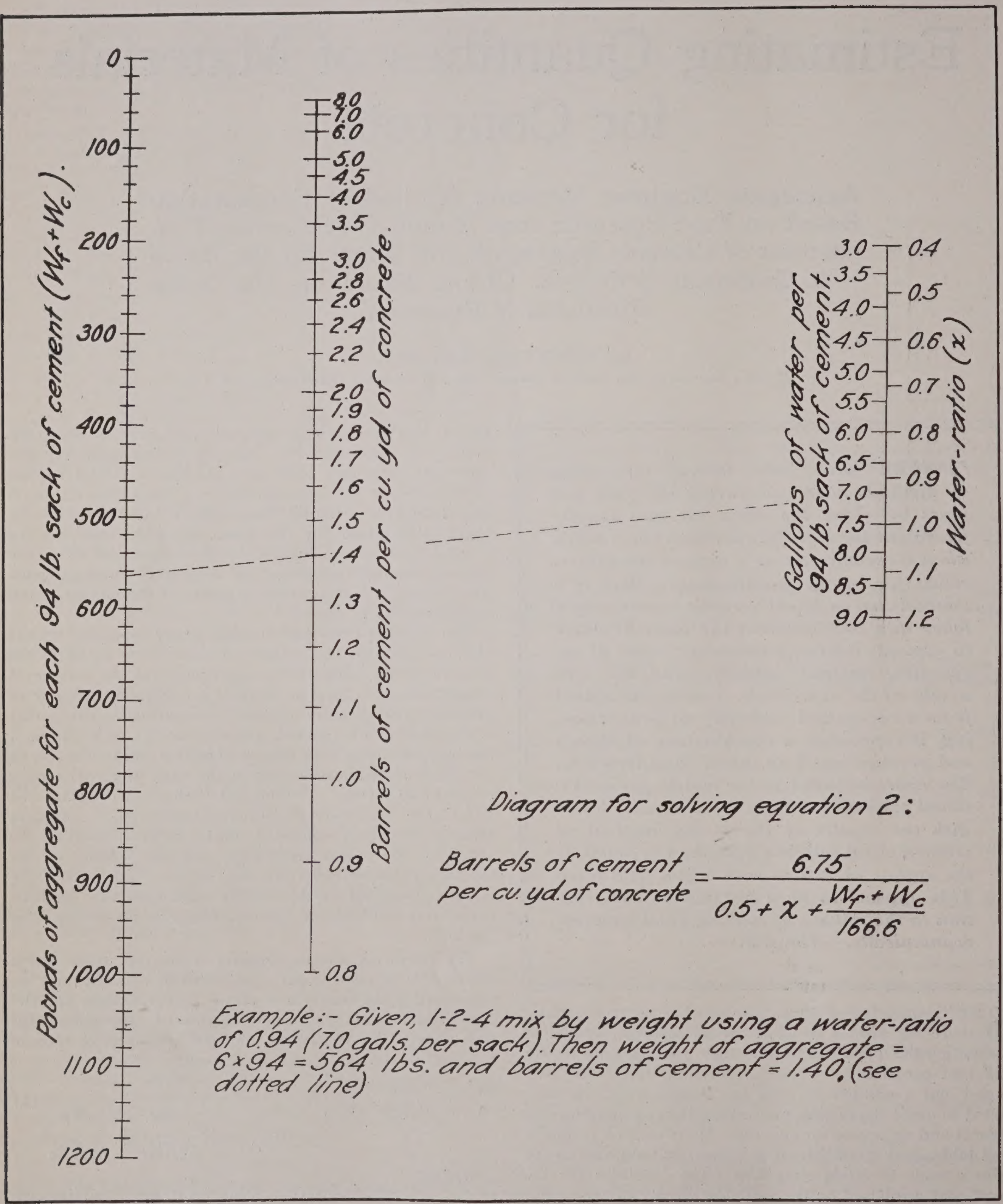

Diagram for solving equation 2:

$$\begin{array}{l}\text{Barrels of cement}\\ \text{per cu. yd. of concrete}\end{array} = \frac{6.75}{0.5 + x + \dfrac{W_f + W_c}{166.6}}$$

Example:- Given, 1-2-4 mix by weight using a water-ratio of 0.94 (7.0 gals. per sack). Then weight of aggregate = 6×94 = 564 lbs. and barrels of cement = 1.40. (see dotted line)

Figure 1. Diagram for estimating barrels of cement per cubic yard of concrete, based on computations explained in the article.

$$C = Vp + Df + Dc \tag{3}$$

Where:

C = Volume of concrete.

Vp = Volume of cement paste.

Df = Volume of solids, (absolute volume), of fine aggregate.

Dc = Volume of solids, (absolute volume), of coarse aggregate.

Vp, the volume of cement paste can be calculated with sufficient accuracy as follows:

$$Vp = Vc\ (0.5 + x) \tag{4}$$

Where:

Vp = Volume of cement paste, in Eq. 3.

Vc = Volume of cement, assuming 1 cu. ft. to weigh 94 lb.

x = Water-ratio; ratio of volume of mixing water to volume of cement, or cubic feet of water per 94 lb. cu. ft. of cement.

Equation 4 is based on the assumption that the volume of cement paste is equal to the absolute volume of cement (volume of solids) plus the volume of mixing water. For an average specific gravity of cement of about 3.12 the number of cubic feet of solids in 94 pounds of cement is $\frac{94}{62.5 \times 3.12} = 0.48$. This value plus the volume of mixing water gives the volume of the paste with a fair degree of accuracy. The use of the factor 0.5 instead of 0.48 does not introduce an important error into the method.

The volume of solids in a given weight of aggregate may be calculated as follows:

$$D = \frac{W}{62.5\,S} \tag{5}$$

Where:

D = Volume of solids in aggregates as in Eq. 1.

W = Weight of aggregate in pounds.

S = Apparent specific gravity of aggregate.

Therefore Equation 3 may be written as follows for the volume of a batch of concrete made with 1 sack of cement:

$$C = 0.5 + x + \frac{Wf}{62.5\,Sf} + \frac{Wc}{62.5\,Sc} \tag{6}$$

For aggregates having specific gravities ranging from 2.60 to 2.70, as most aggregates do have, the substitution of the factor 166.6 (or 1 2/3 × 100) for 62.5 S will not introduce an important error into the method.

Therefore substituting this constant, Equation 6 may be rewritten as follows:

$$C = 0.5 + x + \frac{Wf + Wc}{166.6} \tag{7}$$

Or expressed without symbols:

The volume of concrete produced by one 94 lb. cubic foot of cement is equal to 0.5 plus the volume of mixing water in cubic feet, plus the result obtained by dividing the weight of the aggregate by 166.6.

Equations 1 and 2 come directly from dividing 6.75 (the number of "barrels" in a cubic yard) by Equations 6 and 7 respectively.

Having determined the quantity of cement per cubic yard of concrete from Equations 1 or 2 the weight or volume of fine and coarse aggregate would be found by multiplying the weight or volume of the cement by the number of weights or volumes of the aggregates.

As will be seen from what follows, the method gives results as accurate within 2 or 3 per cent so long as:

1. The concrete is plastic and workable and all voids in the aggregate are filled with cement paste.

2. No water is lost, as in the case of extremely wet mixtures.

3. No important amount of air is entrained as in the case of very dry and lean mixtures and of mixtures of extremely fine aggregate.

Application of Method

The following information is required to apply this method:

1. Proportions of cement to aggregate, either by weight or by volume.

2. The weight per cubic foot of aggregate as used on the job; required only where proportions are expressed by volume.

3. The approximate water-ratio.

For example, consider a 1:2:4 mix by volume. From our knowledge of the aggregates to be used, assume that it is known that the sand weighs 85 lb. per cu. ft. and the gravel 100 lb. per cu. ft. and that from our knowledge of the consistency of concrete which is to be used, that approximately 7 gallons of water, or .94 cu. ft. of water, will be used with each cubic foot of cement. In this mix, therefore, for each cubic foot of cement there is 170 lb. of sand, 400 lb. of gravel and .94 cu. ft. of water.

Then substituting in Equation 2, we have:

$$\left.\begin{array}{l}\text{Bbls. of cement per}\\ \text{cu. yd. of concrete}\end{array}\right\} = \frac{6.75}{0.5 + 94 + \dfrac{170 + 400}{166.6}}$$

$$= \frac{6.75}{4.86} = 1.39 \text{ bbls. of cement.}$$

Or the solution may be made by drawing a straight line in Figure 1 from 470 pounds on the scale at the left to 7 gallons on the scale at the right and reading the intersection on the scale in the center.

From this the volume of sand required is $2 \times 1.39 \times 4 = 11.1$; $\frac{11.1}{27} = .41$ cu. yd. and the volume of gravel, $4 \times 4 \times 1.39 = 22.2$ cu. ft. $= \frac{22.2}{27} = .82$ cu. yd. of gravel.

Had the mixture been expressed in terms of weight the calculations would have been equally simple. Assume that it is desired to determine the quantities of materials per cubic yard of concrete for a 1:2:4 mix by weight for the same water-ratio as above. The weight of sand and gravel for each 94 lb. cubic foot of cement would be as follows:

Sand: 2 × 94 = 188 lb.

Gravel: 4 × 94 = 376 lb.

Then:

$$\left.\begin{array}{l}\text{Bbls. of cement per}\\ \text{cu. yd. of concrete}\end{array}\right\} = \frac{6.75}{0.5 + 0.94 + \dfrac{188 + 376}{166.6}}$$

$$= \frac{6.75}{4.83} = 1.40 \text{ bbls. of cement.}$$

Or the solution may be made by means of Figure 1 by drawing a straight line from 564 lb. on the scale at the left to 7 gallons on the scale at the right and reading the intersection on the scale in the center.

The quantity of aggregate in tons can be readily calculated as follows: Weight of sand per cu. yd. of concrete = 1.40 × 4 × 94 × 2 = 1050 lb. = 0.52 tons. Gravel = 1.40 × 4 × 94 × 4 = 2100 lb. = 1.05 tons.

In the above calculation "4" is the number of cubic feet in a barrel of cement and 94 lb. is the weight of one cu. ft. of cement.

Comparisons with Measured Quantities

Tables 1 to 4 show comparisons of quantities of cement calculated from Equation 2 with values based on measured quantities.

Table 1, which perhaps shows the least favorable comparison of any of the data studied, is made up from Bulletin 9 of the Structural Materials Research Laboratory "Quantities of Materials for Concrete" by Abrams and

TABLE 1

Comparison of Estimated Quantities with Quantities from Bulletin 9

Quantities of cement calculated from proportions in Bulletin 9 of the Structural Materials Research Laboratory; "Quantities of Materials for Concrete," by Abrams and Walker. The values for the unit weights of the aggregates were estimated.

Mix by volume	Size of aggregate: Fine	Size of aggregate: Coarse	Water-ratio	Estimated unit weights lb. per cu. ft.: Fine	Estimated unit weights lb. per cu. ft.: Coarse	Barrels of cement per cu. yd. of concrete: From Bull. 9	Barrels of cement per cu. yd. of concrete: Calculated from Eq. 2
1—2.3	0—No. 4	None	0.9	112	......	2.24	2.30
1—1.5—3.0	0—No. 8	No. 4—1 in.	0.9	108	106	1.56	1.57
1—2.1—2.8	0—No. 4	⅜—1 in.	0.9	112	106	1.51	1.47
1—1.7—3.4	0—No. 4	No. 4—1½ in.	0.9	112	112	1.44	1.40
1—2.3—4.2	0—No. 4	¾—3 in.	0.9	112	110	1.23	1.18
1—1.8	0—No. 4	None	0.8	112	......	2.71	2.69
1—1.1—2.5	0—No. 8	No. 4—1 in.	0.8	108	106	1.82	1.87
1—1.6—2.3	0—No. 4	⅜—1 in.	0.8	112	106	1.83	1.75
1—1.3—2.8	0—No. 4	No. 4—1½ in.	0.8	112	112	1.73	1.66
1—1.8—3.4	0—No. 4	¾—3 in.	0.8	112	110	1.49	1.42
1—1.4	0—No. 4	None	0.7	112	......	3.18	3.14
1—0.8—2.0	0—No. 8	No. 4—1 in.	0.7	108	106	2.27	2.26
1—1.1—1.9	0—No. 4	⅜—1 in.	0.7	112	106	2.26	2.14
1—0.9—2.2	0—No. 4	No. 4—1½ in.	0.7	112	112	2.15	2.06
1—1.3—2.6	0—No. 4	¾—3 in.	0.7	112	110	1.87	1.78
1—0.7	0—No. 4	None	0.56	112	......	4.36	4.41
1—0.4—1.1	0—No. 8	No. 4—1 in.	0.56	108	106	3.51	3.45
1—0.5—1.0	0—No. 4	⅜—1 in.	0.56	112	106	3.30	3.32
1—0.4—1.2	0—No. 4	No. 4—1½ in.	0.56	112	112	3.34	3.16
1—0.6—1.5	0—No. 4	¾—3 in.	0.56	112	110	2.90	2.76

TABLE 2

Comparison of Estimated Quantities with Measured Quantities

Quantities of cement calculated from data in Bulletins of the Structural Materials Research Laboratory, Sand and Gravel Concrete

Data from	Mix by volume	Water-ratio	Relative consistency	Aggregate: Size	Aggregate: Fineness modulus	Aggregate: Unit weight lb. per cu. ft.	Barrels of cement per cu. yd. of concrete: Calculated from measured yield	Barrels of cement per cu. yd. of concrete: Calculated from Eq. 2
Bull. 4	1—7	1.12	1.10	0—1½ in.	5.75	128	0.95	0.95
“	1—4	0.80	1.10	“	“	“	1.57	1.54
“	1—2	0.58	1.10	“	“	“	2.63	2.58
“	1—7	1.28	1.25	“	“	“	0.95	0.94
“	1—4	0.90	1.25	“	“	“	1.55	1.50
“	1—2	0.66	1.25	“	“	“	2.58	2.51
“	1—4	1.09	1.10	0—No. 4	3.05	115	1.48	1.55
“	“	0.96	“	0—⅜ in.	4.00	119	1.55	1.56
“	“	0.86	“	0—¾ in.	5.00	126	1.55	1.54
Bull. 8	1—6	0.92	1.00	0—1½ in.	5.75	127	1.12	1.12
“	1—5	0.82	“	“	“	“	1.31	1.32
“	1—4	0.72	“	“	“	“	1.59	1.58
“	1—3	0.62	“	“	“	“	1.98	1.98
“	1—6	1.00	1.10	“	“	“	1.11	1.11
“	1—5	0.89	“	“	“	“	1.31	1.29
“	1—4	0.78	“	“	“	“	1.57	1.56
“	1—3	0.68	“	“	“	“	1.97	1.94
“	1—6	1.12	1.25	“	“	“	1.10	1.09
“	1—5	1.00	“	“	“	“	1.29	1.27
“	1—4	0.88	“	“	“	“	1.54	1.53
“	1—3	0.76	“	“	“	“	1.94	1.90
“	1—5	1.26	1.10	0—No. 4	3.15	112	1.25	1.32
“	“	1.10	“	0—⅜ in.	3.50	117	1.25	1.32
“	“	0.97	“	0—¾ in.	5.00	126	1.27	1.28
“	1—4	1.09	“	0—No. 4	3.15	112	1.50	1.58
“	“	0.95	“	0—⅜ in.	3.50	117	1.52	1.58
“	“	0.85	“	0—¾ in.	5.00	126	1.53	1.54

Walker. In general the difference between the values given in the tables of Bulletin 9 and those calculated from Equation 1 do not differ more than about 0.07 of a barrel of cement. This small error might readily occur from a slight error in the values which were assumed for the unit weights of the aggregates or due to slight differences in "rounding off" decimals in Abrams' and Walkers' original calculations of the proportions.

Table 2 shows a comparison between values calculated from Equation 2 and values calculated from measured "yields" reported in Bulletins 4 and 8 of the Structural Materials Research Laboratory. The two sets of values show a very close agreement, the average difference being less than 0.03 barrels.

Table 3 shows a similar comparison for data reported in a paper before the 1924 convention of the American Concrete Institute by Pearson and Hitchcock. In no case is the difference between the measured and calculated values more than 0.02 barrels of cement.

Table 4 shows a comparison between barrels of cement calculated from Equation 2 and by Talbot and Richart based on the "mortar-voids" test and the solids in the gravel. The data are from Table 8 of Bulletin 137 of the University of Illinois Engineering Experiment Station "The Strength of Concrete, Its Relation to the Cement, Aggregates and Water," by Arthur N. Talbot and Frank E. Richart. An examination of the table will show a remarkably close agreement in the two sets of values.

TABLE 3

COMPARISON OF ESTIMATED VALUES WITH MEASURED VALUES

Tests from Pearson's and Hitchcock's paper on "Economic Value of Admixtures," 1924 Proc. American Concrete Institute. Sand and Gravel Concrete.

		Barrels of cement per cu. yd. of concrete	
Mix by weight	Water-ratio	Calculated from data in Pearson's and Hitchcock's papers	Calculated from Eq. 2
1—3 —6	1.44	0.95	0.96
1—2½—5	1.20	1.12	1.14
1—2 —4	1.01	1.36	1.38
1—1½—3	0.79	1.74	1.76

TABLE 4

COMPARISON OF ESTIMATED QUANTITIES WITH QUANTITIES CALCULATED BY TALBOT AND RICHART

Data from Table 8, Bulletin 137, University of Illinois Engineering Experiment Station. Sand and Gravel Concrete.

		Barrels of cement per cu. yd. of concrete	
Mix by volume	Water-ratio	Given by Talbot and Richart	Calculated from Eq. 1
1—1—2	0.44	2.41	2.44
	0.53	2.37	2.36
	0.64	2.33	2.28
1—1½—3	0.53	1.78	1.79
	0.64	1.75	1.74
	0.75	1.73	1.70
1—2—3	0.59	1.60	1.62
	0.72	1.57	1.57
	0.84	1.54	1.53
1—2—3½	0.60	1.49	1.51
	0.72	1.47	1.47
	0.85	1.45	1.43
1—2—4	0.61	1.41	1.41
	0.73	1.38	1.38
	0.86	1.36	1.35
1—3—5	0.79	1.07	1.09
	0.94	1.06	1.06
	1.11	1.04	1.04
1—3—6	0.81	0.98	0.99
	0.98	0.96	0.97
	1.14	0.95	0.95

Cost of Engineering Inspection at Owner's Expense

The growing progress toward better inspection of building construction, and in particular the tendency in recent years toward requiring owners to provide competent engineering inspection at their own expense, raises the question of the probable cost of such inspection.

On the assumption that engineering inspection would be continuous from the beginning of concreting in foundations (or the beginning of driving of piles) to the completion of the structural frame, an approximate estimate of the cost of such inspection can be made. It is assumed further that the engineering inspector's daily fee would be $25 on large work and $20 on small jobs, and that the daily charge for each assistant inspector on large work would be $20. An approximate schedule of cost would be about as follows:

	Time on Work			
Cost of Work	Months	Days	Cost of Inspection	Per Cent of Total
$50,000[1]	3	60	$1,200	2.4%
100,000	3	75	1,875	1-⅞%
200,000	4	100	2,500	1-¼%
500,000[2]	6	150	5,750	1-⅛%+
1,000,000[3]	10	250	12,250	1-¼%—
5,000,000[4]	12	300	19,500	4/10%

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[1] On small work one inspector could be engaged on several buildings, if located in the same vicinity. On extremely large work it is necessary to employ two assistant inspectors, one a specialist in structural steel and the other a specialist on reinforced concrete.

[2] One assistant inspector for 100 days.

[3] Two assistant inspectors for 150 days each.

[4] Two assistant inspectors for the full time.

It will be interesting to compare the above schedule of work covered by one man with the value of work covered by a city building inspector. Instances given in the paragraphs that follow are typical.

A survey of the Pacific coast cities whose building officials are most active in the preparation of a uniform building code disclosed that the value of work inspected in one year by one field inspector ranges from $2,000,000 to $5,000,000. It is less, of course, in smaller cities that have one inspector and a small total volume of construction.

In Portland the average is between $4,000,000 and $5,000,000 per field inspector per year.

In San Francisco the average is about $9,000,000 per year for each of the six field inspectors.

In Chicago the average for 50 field inspectors is about $6,000,000 per year for each man.

In Fort Wayne, Ind., where the permit values have been around $11,000,000 per year for the last four years, one field inspector does all building and plumbing inspection.

From these figures it must be quite evident that owners cannot expect the city building department to protect them against builders of a certain unsavory type who undercut the bids of responsible contractors, then make up the difference by the use of inferior materials and slip-shod workmanship.

Some Handy Water-Ratio Tables

Tabulations That Are Intended to Aid the Mixer Man Control the Water—Cement Ratio Batch Without Going To Extensive Computations—a Rule of Thumb Method

By JOSHUA L. MINER

DURING the past twenty years considerable data has been contributed to the art of making strong, durable concrete. One of the most important has been the development of the water cement ratio theory by Duff Abrams. The effect of the amount of mixing water on the strength, porosity and durability of concrete was not fully appreciated until the results of many thousands of tests led Mr. Abrams to formulate the water cement ratio theory.

Although Mr. Abrams made known his conclusions several years ago, application of the theory in actual work was at first slow. There are two reasons, among others, why this was so.

First, many engineers and contractors have not understood the principles of the theory nor have they appreciated its value to them. Secondly, if they wanted to apply the theory they were not always equipped to do so.

Water cement ratio means the relation of the volume of water used in making concrete to the volume of cement. For example, if the amount of water in the concrete as it leaves the mixer is a cubic foot and the amount of cement used is also a cubic foot, the ratio is 1.0. Should the amount of water be 0.86 of a cubic foot and the cement a cubic foot the ratio would be 0.86.

While a bag of cement is generally assumed to be a cubic foot, water is usually measured in terms of gallons, quarts and pints. Even if some of us remember that a gallon of water weighs 8.3 pounds and that 7.5 gallons are equivalent to a cubic foot, we balk at going through the arithmetical process of converting gallons and quarts to cubic feet per bag of cement or vice versa. Consequently instead of referring to the water cement ratio of 1.00 or .86, we now speak of 7.5 gallons or 6.5 gallons of water per bag of cement as the case may be.

However, there are instances when it is desirable to convert the quantity of mixing water from gallons to other terms and for that reason the following table has been prepared. It is based on the following values:

1 cubic foot of cement weighs 94 pounds
1 cubic foot of water weighs 62.5 pounds
1 gallon of water weighs 8.3 pounds
1 cubic foot of water is equivalent to 7.53 gallons

Water Cement Ratio by Volume	Gal. Water Per Sack of Cement	Lb. Water Per Sack of Cement	Lb. Water Per 10 lb. of Cement
.40	3.0	24.9	2.65
.46	3.5	29.05	3.09
.53	4.0	33.2	3.53
.59	4.5	37.35	3.97
.66	5.0	41.5	4.41
.73	5.5	45.65	4.85
.80	6.0	49.8	5.29
.86	6.5	53.95	5.73
.93	7.0	58.1	6.17
1.00	7.53	62.5	6.61
1.06	8.0	66.4	7.05
1.12	8.5	70.55	7.49
1.19	9.0	74.7	7.94
1.25	9.5	78.85	8.38
1.32	10.0	83.0	8.82

Not only does the water added at the mixer combine with the cement but also much of the moisture in the sand and stone. At times there may be enough water in these aggregates to supply all that is required by the cement. Tests on actual work have given results of more than 5 gallons of water in the quantity of sand and gravel required for a one-bag batch of 1:2:4 concrete. Since this water will be present in the concrete when it leaves the mixer and will affect the strength and durability of the cement, it must be included as part of the total amount of mixing water.

Moisture in Aggregates

In order to give some idea of how much moisture there may be in the aggregates used with one bag of cement and how much this may vary in the same quantities of aggregates, the following table has been prepared.

Because of variations in the moisture content of aggregates and different weights per cubic foot for other aggregates, the values in this table are necessarily approximations and only intended to indicate what may be found under average conditions.

Weight of fine aggregate per cubic foot......100 pounds
Weight of coarse aggregate per cubic foot....100 pounds

Moisture in Fine Aggregate	Gal. per Cu. Ft.	Per Cent
Dry	.238	2
Damp	.595	5
Wet	1.071	9

Moisture in Coarse Ag'gate	Gal. per Cu. Ft.	Per Cent
Dry	.000	0
Damp	.119	1
Wet	.357	3

Total Moisture in Gallons Contained in Aggregates Required for a One-Bag Batch for Mixes Shown

Condition of Aggregates	1:2½	1:3	1:2:3	1:2:3½	1:2:4	1:2½:5	1:3:6
Dry	.6	.8	.5	.5	.5	.6	.7
Damp	1.5	1.8	1.5	1.6	1.7	2.1	2.5
Wet	2.7	3.2	3.2	3.4	3.6	4.6	5.3

This table can be employed in a modified application of the Water Cement Ratio Theory. For example, having determined that with 7 gallons of water per bag of cement a 1:2½:5 mix will give a plastic workable concrete, the allowance for the moisture content in the aggregates can be approximated from the values in this table. If the aggregates are dry, it can be assumed that there is probably from 2 to 3 quarts of water in the aggregates and that not more than 6.5 gallons should be added. If the aggregates are deemed to be damp (and generally all washed aggregates when they arrive on the job are damp) only about 5 gallons should be added at the mixer.

It is admitted that such a procedure is "by rule of thumb" and does not offer any great accuracy in results. It, however, does offer some measure of control of the amount of mixing water.

Old Arch Bridge in Good Condition

A Pioneer Reinforced Concrete Arch Bridge, the Wayne St. Bridge Over the Wabash River at Peru, Indiana, Shows but Few Defects After Twenty Years' Service—Exposed to Severe Floods—How the Bridge Was Designed and Built—Comments Upon the Methods Used in Light of Present Condition

By NORMAN M. STINEMAN

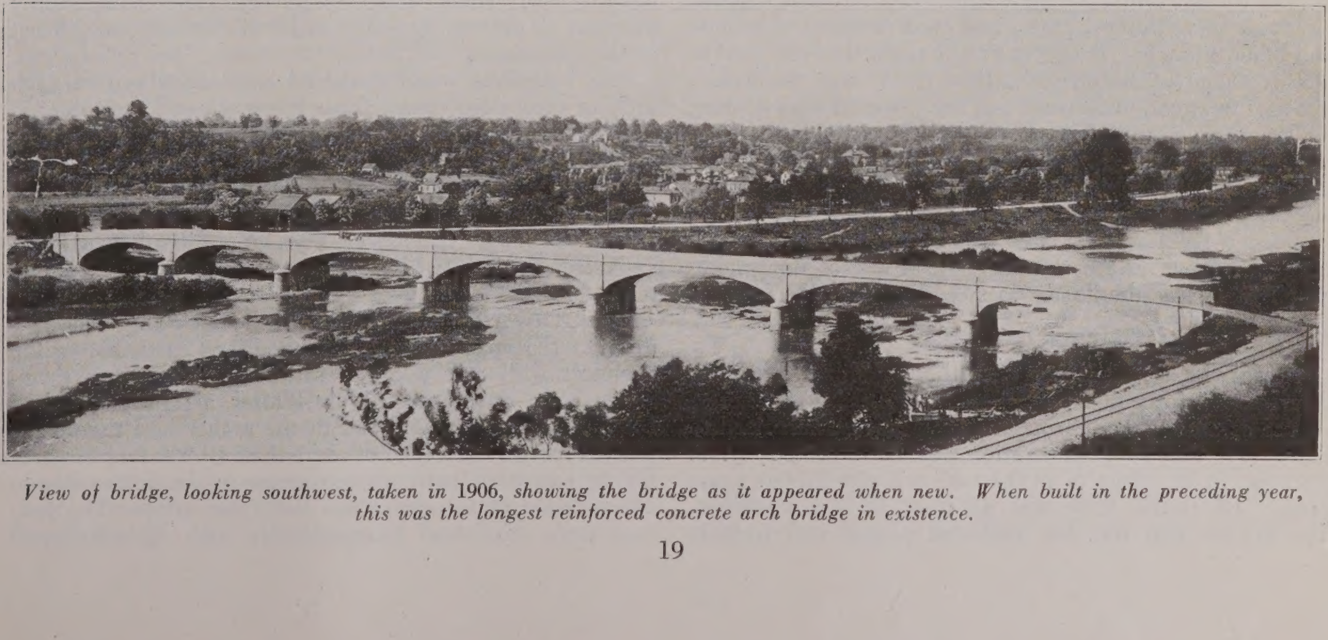
THE service records of very few reinforced concrete arch bridges extend back more than a quarter of a century. It is true that arch bridges of that material erected 20 or 25 years ago contain some structural features that would no longer be considered good practice. They were built at a time when much remained to be learned about the making and placing of concrete, and when the designer had but little previous experience to draw on. Consequently an engineering examination of concrete structures of that period should be careful to include investigation of special features with respect to which standard practice has changed. This report should therefore be of great interest, prepared as it was by an engineer who is well versed in the subject.—The Editors.

The record and present condition of the reinforced concrete arch highway bridge crossing the Wabash River at Wayne Street, Peru, Indiana, is of exceptional interest because of its importance as an engineering structure when it was first completed. The structure, completed in December, 1905, has been in service 21 years. It has seven arch spans of the barrel type varying from 75 to 100 feet in the clear. The total length is 700 feet and the width of the arch barrels is 30 feet.

At the time of its construction the Peru bridge was given much prominence in engineering literature, both in this country and in Europe. Even French and German engineering text books of that period included as much as a page and a half of illustrated descriptive matter pertaining to this structure. It was the longest reinforced concrete arch bridge then actually completed, although it was only about 50 feet longer than a somewhat similar bridge built over the Kansas River at Topeka, Kansas, in 1897. The Topeka bridge, however, while similar in external appearance, is in reality a different type, known to engineers as the Melan type, in which the steel reinforcement consists of riveted steel arches of light structural steel shapes. The Peru bridge, on the other hand, is the true reinforced concrete type as we know it today.

A Low Cost Structure

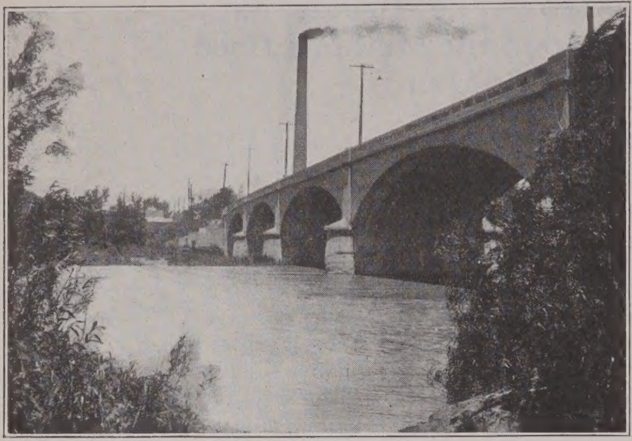
It is probable that the interest in the Peru bridge was due in great measure to its surprisingly low cost rather than to the size of the structure. The contract price for the bridge was $36,900, and that is said to have been about the actual cost to the contractor. This represented a cost of only $1.76 per square foot of horizontal area. Among engineers and builders there was an inevitable comparison with the Topeka bridge, which, with a horizontal area of 26,000 square feet, cost $125,000, or $4.81 per square foot of horizontal area. In fairness to the builders of the Topeka bridge it should be said that the contract price included the cost of removing an old steel bridge and placing it on temporary piers for the use of traffic during the construction of the concrete bridge. That, however, accounted for only a small part of the difference in the unit cost of the two structures.



View of bridge, looking southwest, taken in 1906, showing the bridge as it appeared when new. When built in the preceding year, this was the longest reinforced concrete arch bridge in existence.

Subjected to Severe Floods

The record of the Peru bridge would not be complete without a brief reference to the extreme flood conditions to which it has several times been subjected. High waters are an annual occurrence in the Wabash River, as in other rivers. In January, 1907, a little more than one year after the completion of the bridge, it was subjected to a flood that reached a high water level within 8 inches of the former record, and was within three feet of the crowns of the arches.



View, looking north, taken in 1926, *showing four of the seven spans. The third pier from the north end, shown in the foreground, has undergone some damage, perhaps from floating ice.*

But it remained for the Easter floods of March, 1913, to give the structure its most severe test. A combination of four days of continuous rainfall on frozen ground apparently produced a 100 per cent run-off and raised the flood waters in many streams in Indiana and Ohio to levels never before recorded. The total precipitation was from 5 to 7 inches. The Wabash River rose far above previously recorded levels, and the Peru bridge was submerged to the coping just below the base of the railing. That is, the arches themselves were completely submerged. The river was full of debris, consisting partly of the wreckage of the equipment and property of the Wallace-Hagenbeck circus, whose winter quarters were located about a mile upstream. When the flood was at its highest the C. & O. railway bridge, crossing the river at an angle a short distance upstream, deflected the current through a lumber yard, carrying the lumber into the river and lodging it against the north end of the concrete bridge. Mingled with the lumber was the circus property, consisting of tents, wagons, wreckage of buildings, cages, and even drowned elephants and other animals. It was at first thought that the lumber and wreckage were obstructing the flow through the bridge, but an investigation showed that the material was floating on the surface and that all the arches were discharging their full capacity. As the water level fell, the lumber began to pass through the north three arches, whereupon it was salvaged by anchoring it at the bridge with booms suspended from ropes. These ropes can be seen hanging over the railing at the nearest span in one of our photographs, taken as the flood was subsiding.

No Bad Flood Damage

Those who are familiar with the organized efforts to discredit reinforced concrete almost from the beginning of its use as a construction material will not be surprised to know that this very illustration has been used for that purpose, in an effort to prove that concrete arches cause jams! Of course there was no truth in that statement. The lumber that was not anchored passed very quickly through the bridge when the water surface fell below the crowns of the arches.

While it is not probable that the lumber and other material anchored above the bridge caused much of an overturning pressure against the structure, it is said that this floating material was responsible for marring several of the piers. Otherwise no damage occurred to the bridge.

Proof of the severity of this flood was not hard to find, for in a stretch of 60 miles along the Wabash River the Peru bridge and a similar concrete arch structure at Georgetown, Indiana, together with two steel bridges, were the only highway bridges that remained standing. Six steel highway bridges were destroyed.

Method of Construction

Before discussing the present condition of the bridge something should be told of the manner of its construction. The foundations for the piers and abutments were carried to bed-rock, ranging from 6 to 16 feet below low water level. The bridge was built from the south bank, where the concreting plant was located. The concrete was distributed from the mixer in side-dump cars of ½ cubic yard capacity, on a track built over the successive spans and shifted from side to side of the roadway. From these cars the concrete was dropped into place from heights as great as 30 feet. In the concreting operation the south abutment and the first pier were first placed to their spring lines, then the arch ring of the first span, then the second pier, then the arch ring of the second span, and so on. The arch rings were built in two longitudinal strips each 12 feet wide and continuous from pier to pier. Across the longitudinal construction joints thus formed, five ¾-inch round rods were placed in each span. These joints, though of course plainly visible, show no present indication of separation or disintegration. In concreting successive spans the arch rings of one span were continued across the pier and ended at the skewback of the next span. A 3-foot width of arch ring under each spandrel wall, and the spandrel walls themselves, were then concreted at the same time, to avoid construction joints on the vertical face of the bridge between the spandrel walls and the arch ring.

Thus each arch span has three longitudinal construction joints in the arch barrel, one transverse construction joint at the springing of each pier, and one at the south skewback.

Preventing Scour

In each end span a concrete pavement was placed in the bed of the stream, reinforced longitudinally from abutment to pier. These reinforced pavements serve the double purpose of preventing scour and resisting the arch thrust at the abutments.

The spandrels were concreted continuously over each arch in successive spans, from the south end, but at each pier a space of five feet was omitted and was concreted at a later date, along with the buttress and ice-breaker. Thus a joint in the nature of an expansion joint was provided at each end of each spandrel. However, reinforcing bars extend across the joints, so that in reality they are not expansion joints within the meaning of present-day terminology.

The transverse reinforcement in the arch ring was bent up into the spandrel and extended vertically above the spandrel wall and into the railing. The railings themselves were not concreted until after all falsework had been removed from underneath the arches and the bridge carried its full dead load of more than 10,000 tons of earth fill, so that practically all settlement of the arches due to compression of the arch rings had taken place. The railings were reinforced longitudinally with ¾-inch round rods, which also continued through the joints at the pedestals over the piers.

Records of Mix

The structure utilized about 5,000 cu. yds. of concrete. According to the description previously given, the concrete was mixed in the proportions of one part of portland cement to five parts of unscreened pit-run gravel. The designer and builder of the bridge, however, informs us that his recollection is that the mixture for the main part of the bridge was one part of cement to seven parts of the separate volumes of sand and gravel, while the pier caps were somewhat richer in cement and the railings were of 1:3 cement-and-sand mortar.

While there is consequently some question as to the exact proportions used, there seems to be no doubt of the use of unwashed and probably unscreened pit-run aggregates. The use of pit-run material and the absence of true expansion joints such as would now be provided were considered proper enough at the time, but were contrary to what would now be accepted as good practice. The bridge is virtually a continuous structure 700 feet long, without articulating expansion joints.

A feature that gives the bridge a somewhat unsatisfactory appearance is the matter of camber. The county engineer insisted on having the crowns of all arches except the two end spans at the same level. This necessitated placing all the camber in the end spans.

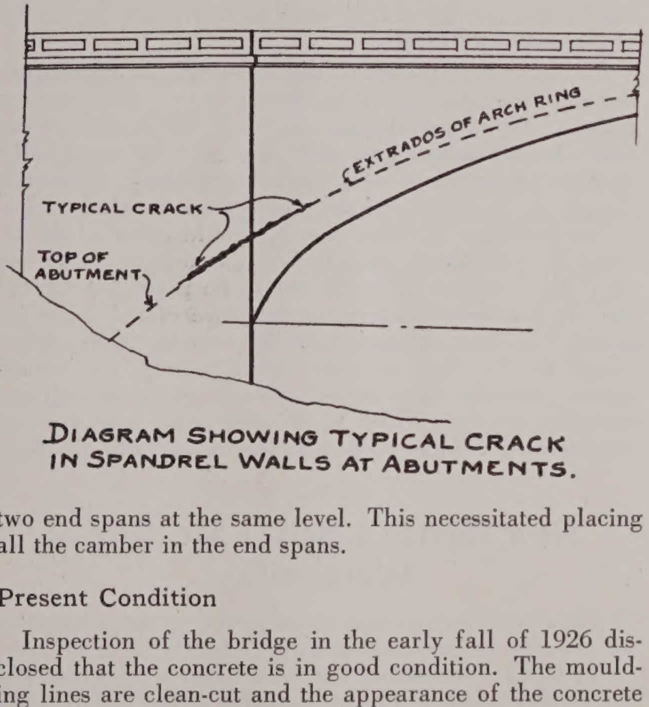


DIAGRAM SHOWING TYPICAL CRACK IN SPANDREL WALLS AT ABUTMENTS.

Present Condition

Inspection of the bridge in the early fall of 1926 disclosed that the concrete is in good condition. The moulding lines are clean-cut and the appearance of the concrete is good, with the exception of the railings and most of the pier caps. The concrete (or mortar) in the railings has a yellowish color and appears to be of somewhat poorer quality than the concrete in the main parts of the structure. Since the railings are not a structural part of the bridge and were placed some time after the rest of the concrete work was completed, it is not improbable that this work received less careful supervision than the main concreting operation received. At several points in the railing the reinforcing steel is exposed where it was placed too near the forms, and the concrete was broken off. At these points the continuation of the longitudinal reinforcing bars through the joints between the pedestal and the railing can be seen. Small vertical shrinkage cracks have developed in the railings at irregular intervals averaging about 10 feet. These are not large and will not be noticed by a layman.

The three longitudinal construction joints in the arch barrel and the transverse construction joints previously described were found to be intact and show no tendency to open up or disintegrate.

View of bridge, looking south, taken as the 1913 *flood was subsiding. Debris from lumber yard was saved by means of boom suspended from bridge, as shown in this view. Circus wreckage may also be seen in this picture.*

The Abutment Cracks

The most serious cracks that have developed are in the abutment wings, the wings being extensions of the spandrel walls. The cracks may be due to the efforts made by the structure to provide room for expansion. The designer of the bridge, however, gives us an explanation that seems more probable. The wings, or spandrels, were designed with an insufficient width of base and soon began to yield at the point of contact with the abutments. As shown in our line drawing, the tops of the abutments were a continuation of the extrados of the arch rings. When the yielding was observed, reinforced concrete ties were built from one wall to the other, under the roadway. At least the cracks then formed were the beginning of the larger cracks that now appear. The cracks extend in each direction from an imaginary vertical line drawn upward from the face of the abutment, and they partly separate the spandrel wall from the arch ring and the abutment. A typical crack is shown in our line drawing. On the east face at the south abutment this crack is about 10 feet long, and 12 or 15 feet on the west face.

Similar cracks, shorter and less serious, have developed at the north abutment. The one on the west face at the north abutment is the least serious of all. These cracks are not of a serious nature from the structural standpoint, for they affect only the eventual stability of the walls themselves; but for the sake of appearance, and also to prevent further corrosion of steel or disintegration of concrete, it would be well to chisel out the cracks and refill them with a light-colored elastic waterproofing material. They should not be refilled with mortar, for if they were caused in part by an expansion movement one may be certain that the movement is still in action. The cracks should be recognized as expansion joints and treated as such.

Other Effects

There is considerable map-cracking in the cap of the fourth pier from the north end. Similar cracking of smaller extent has developed in all the pier caps. It was in these caps that a richer mixture of concrete was used—perhaps too rich. The caps of the third and fifth piers from the north have several pieces of concrete broken off the projecting part, probably caused by floating debris.

Considerable wearing of concrete, as from the grinding action of ice, has occurred in the third pier from the north end. Curiously enough, the worst wear is at and near the downstream end of the pier. This may be seen quite clearly in our reproduction of the photograph taken in 1926. At one point, near the downstream end of the pier, the spalling, or erosion, or whatever it may be, is about 6 inches deep. Similar damage, but of much less extent, has occurred in the first and second piers from the north end. These three piers are situated in the main part of the current.

Surface drains were not installed, so that all drainage of the earth fill between the spandrel walls is carried through weep-holes, of which there are two at each end of each arch barrel.

As might be expected, this drainage causes discoloration of the concrete below the weep-holes.

Summary of Report

To recapitulate, the bridge is in good condition, even though it was built at a time when so much remained to be learned about the design and construction of reinforced concrete structures. Not a dollar has been spent for repairs on this bridge in the 21 years of its service. It would, however, be advisable to make the repairs already suggested, with respect to the cracks in the wing walls at the abutments.

The Peru bridge was designed by D. B. Luten, consulting engineer, Indianapolis, and built by the National Bridge Company, of the same city.

Distributing Cement-Bag Costs

How One Cement Maker Maintains a Sack Supply of Uniform Quality and Equalizes Renewal Charges

The average life of a cloth cement sack is calculated to be from eight to ten trips. Consequently, when the cement user receives a carload of cement packed in cloth sacks, he finds sacks of varying ages. As he must pay for those sacks that wear out in service as well as for those that are lost, diverted to other uses or made unfit for further use because of damage by water or other agencies or torn beyond repair through misuse, one user should not be penalized to the advantage of another by paying for more than the average percentage of worn out sacks. The practice of one large cement manufacturer in handling the distribution and shipment of sacks is to equalize their cost by supplying a uniform quality of containers to all his customers.

Each individual shipment, as received at the plant, is cleaned and the sacks classified according to condition as "Good," "Repairable" and "Useless." "Good" sacks are those that contain no holes or tears and have not been allowed to get wet. "Repairable" sacks are those that have been more or less torn but that can be put in serviceable condition through a reasonable amount of mending. "Useless" sacks, of course, are those that are worn out or have been damaged by water, rough handling or misuse, and can, therefore, be no longer used as cement containers. Full refund of the sack charge is allowed for both "Good" and "Repairable" sacks.

As cement packages are filled on Bates' packers through a valve opening in the corner, the cloth sacks are tied first. The cement maker determines the number of new sacks he must put in service during a given period, and in order to spread these evenly over his shipments during that period, calculates the percentage that should be used in each day's operations. The percentage of repairable sacks received from his customers runs very uniform. By keeping the repairing of these sacks up to date, he is able to add to the bundles containing the good and the new sacks a percentage of repaired sacks equivalent to the percentage returned to the plant. In this way, each bundle of 50 sacks, as it goes to the tying room, contains the proper ratio of sacks of each grade. For example, if the percentage of new sacks required proves to be 10 and the percentage of repaired sacks coming back to him is 16, each bundle of 50 sacks contains 5 new, 8 repaired and 37 good sacks. By this arrangement, each and every car of cement loaded contains a like proportion of new, good and repaired sacks and each customer is treated alike as regards the quality of the sacks he receives.

As the costs involved in the cleaning, sorting, inspecting and repairing operations become a part of the cement maker's cost of manufacture, the only direct package cost borne by the cement user is his payment for sacks which he does not return or which he sends back in useless condition. If the cement maker should treat the cloth sack as a free package—in other words, should allow credit for every sack returned regardless of its condition—the user who takes care of his sacks would be penalized through the carelessness of others, as the price of the cement in which this item of cost would have to be taken care of would be the same to both. Consequently, this cement maker feels that the method of procedure as outlined, based on a policy which he believes is the only fair and equitable one, works to the best interests of his customers.

New Device a Better Measure of Workability

During the course of an investigation on the workability of concrete, in conjunction with a manufacturer of a material that is intended to aid in securing a workable mix, the United States bureau of standards found that the ordinary penetration device previously perfected would not give as reliable results on lean or harsh mixes as could be desired. The bureau modified, as a result, the apparatus and better results were obtained. In the new device the rod is driven into the sample by means of a weight dropping onto the end of the rod. This weight is rigged up quite like the hammer of a pile driver. The workability of the concrete is measured by the reciprocal of the work done in driving the rod into the material. Still another apparatus, depending upon a different principle, is being considered, as a still better measure of workability. After the best apparatus is perfected a wide range of mixes will be investigated. The tests so far indicate an increasing workability as water is added to the mix until a certain point is reached, where too much water is added and segregation begins to be manifest. Beyond this point workability decreases.

Winter Construction

as applied to

Reinforced Concrete Work

Some Reasons Why Concrete Construction Should Go on Through the Winter and Some Advice on How It Can Be Done

By VIRGIL L. JOHNSON
Structural Engineer, Board of Public Education, Philadelphia

CONSTRUCTION in general is the cause of great business activity in certain lines. Especially so in concrete work, for it takes sand and gravel from the pits, cement from the plants and reinforcing steel from the mills to say nothing of the millions of feet of lumber from the forests.

We, as a nation, are now in the midst of the greatest era of prosperity that this or any country of modern times has witnessed and it is possible that we are just launching forth upon a wonderful period of building beautiful structures as well as structures that are utilitarian.

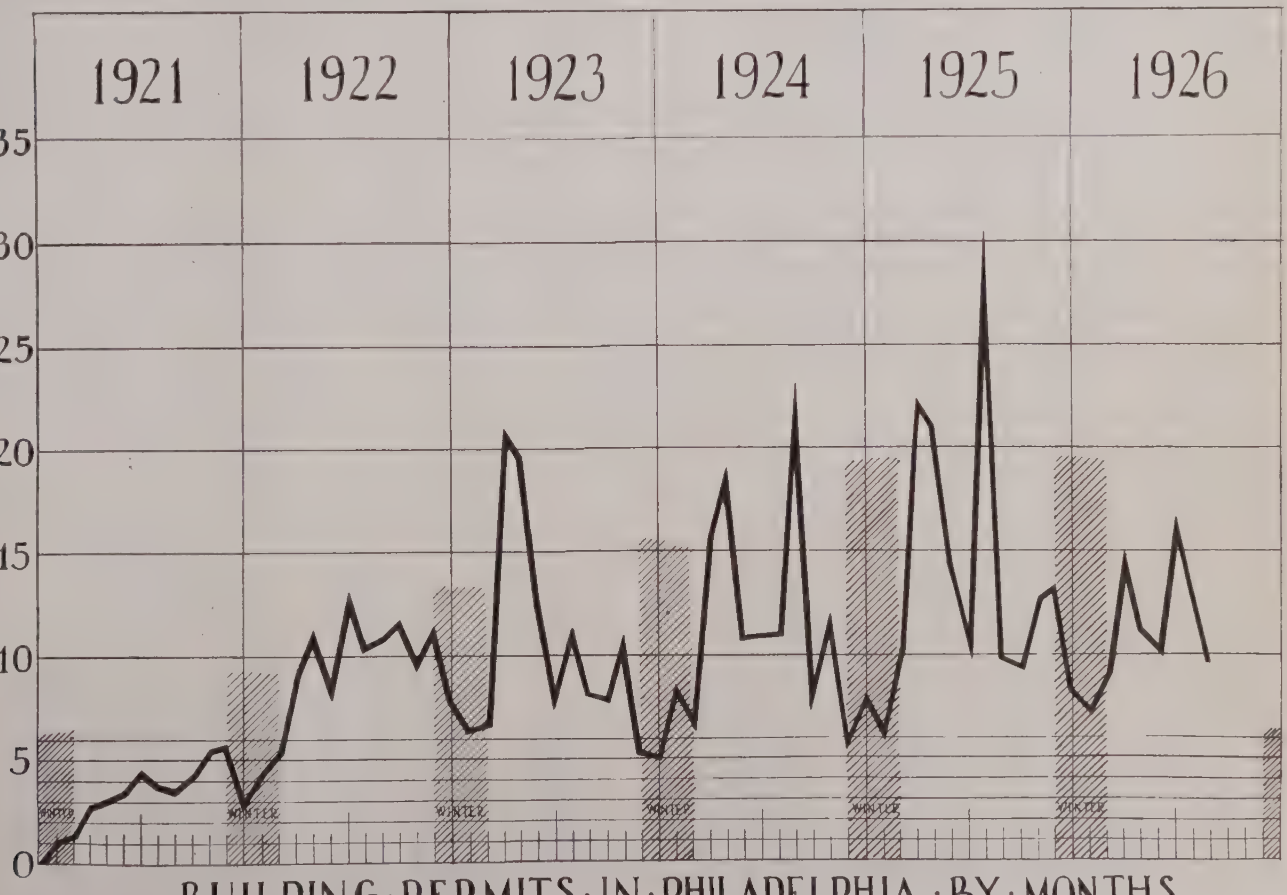
No Need to Wait

Why wait for the spring or summer months to commence on your program? If you have a building to erect, the time to go ahead with it is now, when others are not building.

Bankers will tell you that the time to buy stocks and bonds is when nobody wants them. Architects, likewise, will advise you to build when few are building.

You will notice on the accompanying graph that there is a decided falling off in the Philadelphia building permits from late in fall until well into spring, and that these permits are at the lowest level during December, January and February. This falling off is due, we are led to believe, to the traditional fear of winter weather.

Really, there need be no fear. There should be no hesitancy in doing that which someone else has done. Winter construction is no longer an experiment for it



BUILDING·PERMITS·IN·PHILADELPHIA·BY·MONTHS goes on everywhere and there is no reason why it should not be encouraged and developed.

An early example of cold weather work in winter of 1920-21 was the erection of the great store and warehouse of Sears-Roebuck & Co. in Philadelphia. It was a spectacular event at that time. The great structure was wrapped in flopping tarpaulins but even on the coldest days the work proceeded without a break. There were many Philadelphians at that time who thought Sears-Roebuck were doing a foolhardy thing to proceed with that construction under such difficulty, but a trip through that plant today will convince one that they knew their business and that they were prepared for the wonderful business activity of 1924-25 and 1926.

The Sears-Roebuck Company's building is not the only striking example of winter construction, for there have been many others since then that are quite as important and just as spectacular. For example, the Board of Education of Philadelphia has recently opened a new Senior High School with a capacity of 3,800 and costing over two and one-half million dollars on which work went on regardless of weather.

This school was awarded two days before Christmas of 1924, and on the day after New Year's Day, 1925, actual work was started with the concrete work proceeding regardless of weather. On January 21, the contractors began to pour the concrete footings and columns. They were ready for the first floor slab by April 1. By referring to the graph of Philadelphia school contracts you will notice that some of the very largest contracts were awarded in cold weather.

The Board of Education has always gone ahead without regard to season or weather. There are as many schools placed under contract during the winter months as in the good old summertime.

There have been some notable examples of winter construction in the northern sections of the country. One of the most striking examples is an office building in the city of Toronto, erected in 1923. This building was started in October and completed within nine months. During the coldest winter weather when the thermometer went as low as 50 degrees below zero it was built at the rate of a story a week. This structure is the highest concrete building in the British Empire.

In Chicago one of the largest concrete buildings in the world was built of reinforced concrete in the midst of winter.

In Alberta, Canada, a few years ago, a summer resort on Lake Louise burned in the fall. The owner immediately began construction of a ten-story building and had it ready for the summer tourist in June. And this work was done when the temperature was registering 50 degrees below zero.

Winter Construction Methods

Concrete is a mixture of cement, sand, stone and water. It is a freezable material and owing to its chemical composition requires both moisture and warmth to promote strength. It requires a temperature of 70 degrees F. for 28 days to reach its full strength of 2000 lbs.

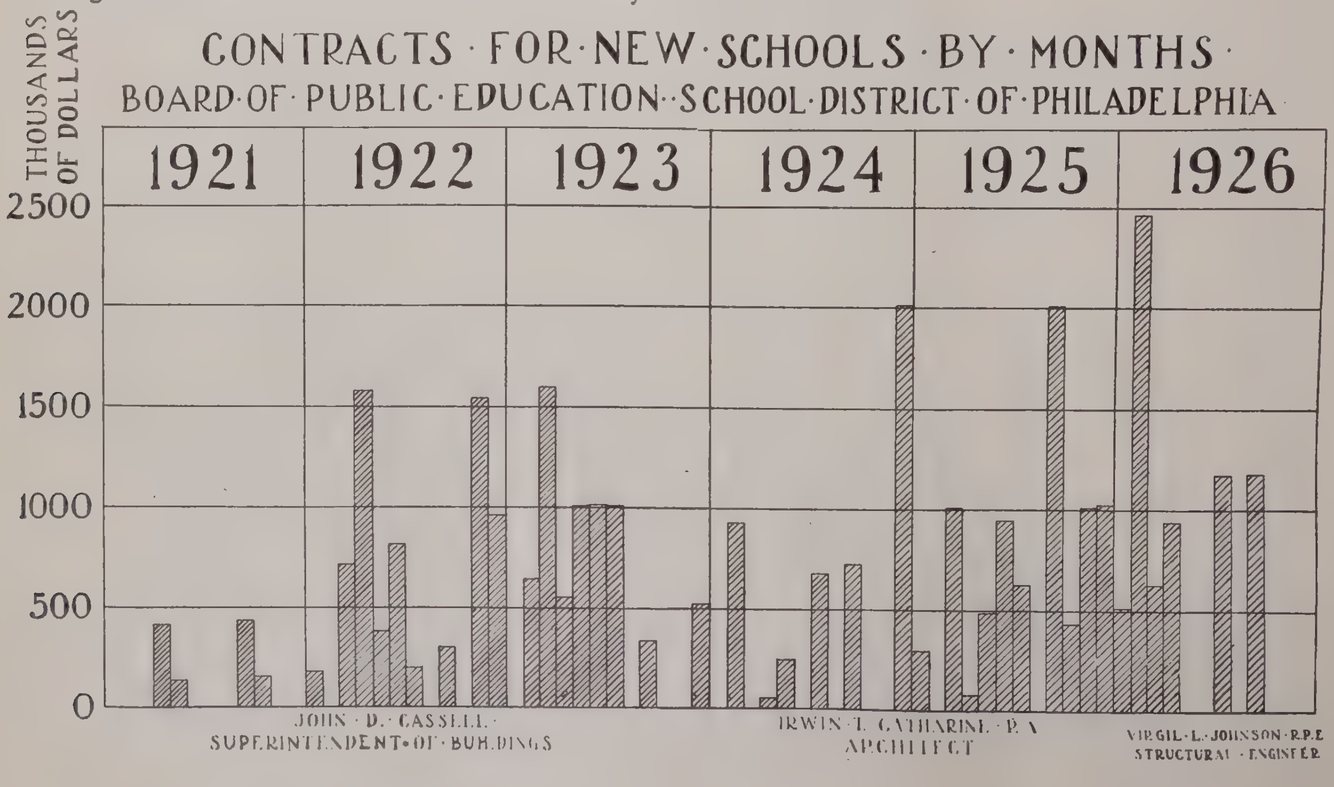
It is necessary to heat the aggregate by fires or steam pipes, to heat the water and, if necessary, to inject a flame into the mixer. With these precautions the concrete goes into form steaming hot, at a temperature of about 120 degrees.

Concrete is made hot by a flame in the mixer as well as the heating of the sand and pebbles with steam pipes or fires. Water is heated to boiling temperature and everything is ready for zero weather.

As soon as possible after the first floor is poured, the concrete is covered with hay and tarpaulins in order to hold the heat as long as possible.

The sides of the building are enclosed in tarpaulins and salamanders are placed below the forms and at the sides of columns, insuring a steady warmth. Heat is kept in the concrete by covering the top with a foot of marsh hay.

There is nothing new in the methods that have been described. They have been used time after time with the best of results. Winter work is no longer an experiment. The benefits derived by many progressive contractors have proven its practicability and desirability beyond the shadow of a doubt.



EDITORIALS

Monolithic Concrete Surfaces

PERHAPS one reason why the artistic possibilities of concrete are not generally appreciated is the fact that concrete is so well-known as an all-around useful material. An every-day material with such substantial qualities as concrete possesses is not often associated with the beautiful.

Yet some discerning builders have seen its possibilites for beauty and have benefited by applying them. In some localities architects prefer unadorned concrete as the surfacing material for the structures they build. When properly made in well-built forms, the "raw" concrete has produced surfaces of outstanding beauty.

There is also the element of economy. A relatively slight additional cost in better form work and greater care in mixing and placing does away with the need for a considerable expenditure for "veneer."

When the structural unit of the building can easily be designed to provide the facing also, the resulting savings are evident. And when that structural material, by its very nature, provides a surface that is considered by many architects and artists of unusual beauty and distinction, its ultimate popularity is assured.

A Sales Problem

THE concrete contractor, even if he is loath to admit it, has found that he, also, has a sales problem. He must sell his ability and services to prospective buyers. He must sell the material he specializes in and must sell his organization as the men best qualified to do the job.

There are many new contractors in the field, some of whom are inexperienced in concrete work and, unfortunately, some of whom are unable or unwilling to make a bid that will permit a fair profit for honest work.

The dependable concretor has much to offer to the prospective builder. A reputation of long standing for honest construction has a real sales value. Financial responsibility and an experienced organization with a record for accomplishment are points that the architect and owner are very much interested in. The concretor that is the possessor of such advantages is neglecting an opportunity if he does not bring them to the attention of architects and prospective builders.

The lowest bid is not the only determining factor in the award of a contract. Speed of performance and quality of work are factors that are beginning to receive the consideration they warrant.

Your Association

THE time is approaching when products men will meet with their associations to discuss problems of mutual interest.

Many associations have been able to accomplish much for their members. Others have not.

The success or failure of such organizations depends largely on the spirit in which they were organized and the policies under which they function. The benefits that come from frank discussions of common problems, while they are of great value to members, are nevertheless, only a small part of the advantages of association membership. By far the greatest benefits that the products manufacturer can secure from his association have to do with its relations to the construction industry as a whole—and more particularly with the possible buyers of concrete products.

The spirit of the successful associations is one of service to the user. Cooperation with city building departments in testing products and maintaining quality; cooperation with the architect, the builder, the materials dealer and the user and the establishment of a reputation for fairness and reliability are some of the most important things a products manufacturer's association can do. They have a direct and important reaction on sales, and that, after all, is the final object of all associations.

The products manufacturer should come to his meeting prepared to take part. As in any other organization, the man who gives most gets most. The social side of the meeting is of importance, of course, but in the last analysis, the meeting of the manufacturers is a serious one with a serious object.

Fire-Safe Roofs

A RECENT survey made by the National Board of Fire Underwriters shows that at least 169 American cities now prohibit the use of wooden shingles within their corporate limits. Other cities, not included in the count, prohibit wooden shingles in certain areas only.

Concrete tile makes fire-safe roofs. Their increasing popularity is due to the combination of qualities they possess—fire resistance and beauty. A tremendous field, as yet practically undeveloped, awaits the concrete roof tile manufacturer.

The greatest gain in construction in recent years was in residential buildings. Every new residence and a large percentage of old homes are legitimate prospects for concrete tile. Their beauty is acknowledged. And now city ordinances are increasing the market and giving the tile salesman one of his best arguments.

Building Concrete Sidewalks by the Mile

Use of Paving Methods on Sidewalk Work Led to a Third Reduction in Cost—Methods Used by the Contractor—a Better Sidewalk

By JAS. F. ROSE
City Engineer, Hibbing, Minn.

SEVEN and one-half miles of one course concrete walks 6 feet wide were laid in Hibbing the past season at a cost about two-thirds of that paid previously. That was made possible by applying to sidewalk construction the methods and tools which have been used in the quantity production of concrete pavements.

The contractor, E. W. Coons, has built much of the concrete pavement laid in Hibbing in recent years and has several paving outfits. On a siding at the edge of the city he has a central proportioning plant which is so efficient that four men can unload and batch 100 carloads of aggregate per week without the aid of any machinery. In this plant all the materials are handled by gravity. Mr. Coons constructed an approach to his dock from a siding on the D. M. & N. Ry. The plant consists of a cement shed, five sand bins and seven stone bins. A standard gauge railroad siding runs out over the bins so that material in bottom dump cars can be dropped directly into any bin desired. Each bin holds about 40 cubic yards and has a slanting chute down which the material slides to the truck and in which the sand or stone for one batch is measured. The driveway under the chutes is about four feet below the general ground level.

Bulk Cement Used

Bulk cement is used. It is transferred from the box cars in which it arrives to the cement bin by two men who work under contract. They handle it much as grain is handled, with a large snowplow-like scoop on two wheels. It takes four hours to unload a car. The cement for each batch of concrete is measured in volumetric hoppers. There are two of these hoppers each hung on an overhead track. When they are to be filled they are pushed under the cement chute. When they are filled and the truck is in position they are pushed out over the runway and the cement is dropped into the two compartments of the truck. One man easily measures and dumps all the cement needed. It is usually very difficult to get cement to run smoothly from a chute. Either it will not run at all or, on being jarred, it drops in such a mass that any measuring box is filled to overflowing. This has been entirely eliminated in the Coons plant by running a small pipe from the bottom of the chute, just behind the gate, up to the roof of the cement bin. The pipe provides an air vent which relieves any vacuum in the chute and causes the cement to run out evenly.

It is generally believed that cement cannot be accurately measured by volume, but a careful check of the weight of cement in the car against the batches of material sent from the plant indicates that this method is satisfactory. Perhaps the fact that the cement is handled once before it is measured accounts for its apparent uniform density in the measuring hoppers.

Delivers Dry Batch

Proportioned five sack batches from this plant were hauled to the paving mixer on the sidewalk job in trucks. Materials were washed sand and ¼- to 2-inch pebbles proportioned 1:2:3½. The mixer ran along the edge of the street, eight feet from the edge of the walk when there was no curb and 9½ feet when it must keep outside a curb. The concrete was dropped directly into place in the walk by the mixer, which had a boom and bucket.

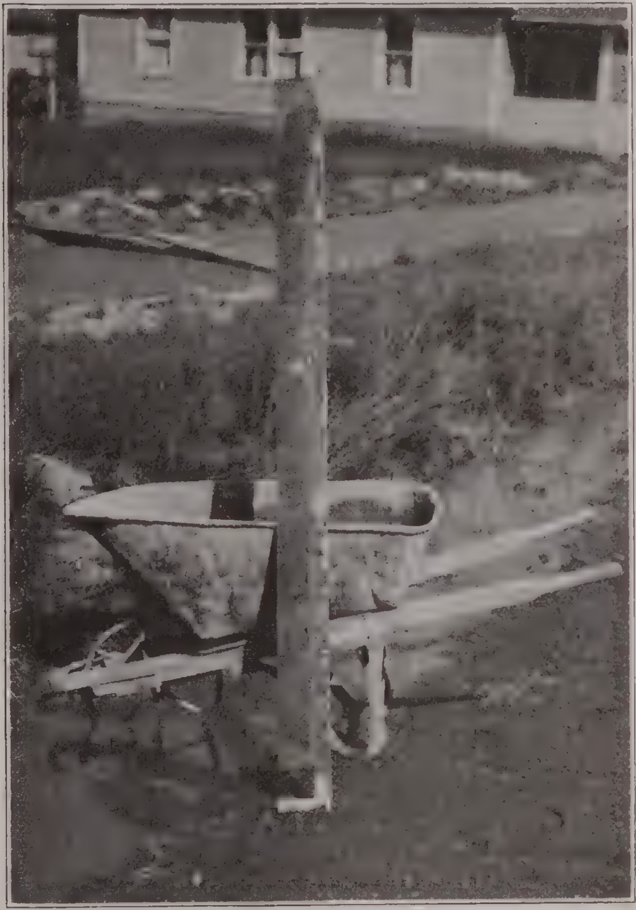
Sidewalk work progressed rapidly when done with a regular paving organization and appropriate equipment.

This handy device made rapid the striking off of the sand sub-base.

Forms were set and the subgrade was finished and rolled far ahead of the mixer, so that there would never be any delay. The forms were 3 by 6's, dressed down to 2¾ by 5¼, staked and braced at 10-foot intervals. These heavy forms more than saved their extra cost over the 2-inch material ordinarily used because they required so much less staking to keep them in line.

After the forms were set the subgrade was planed off to a depth of five inches below the bottom of the slab. This space was filled with a five-inch gravel sub-base which was struck off, rolled, then again struck off with a long-handled, wheeled template which ran on the forms and had a metal cutting blade.

Just before the concrete was placed the subgrade was sprinkled, the forms were oiled and metal division plates three-sixteenths of an inch thick were placed transversely between them. These plates had a width of five inches, which was the thickness of the sidewalk. On each end there was a notch which fitted over the forms while the metal above the notch slipped into saw kerfs an inch and a half deep which had been cut in the forms at six-foot intervals. The plates divide the sidewalk into six-foot blocks with joints which go clear through the slab and eliminate all possibility of contraction cracks. After the concrete is placed the plates are raised a little to prevent any bonding, and when the concrete has hardened so that it will not flow in and fill the cut the plates are removed and the joint is edged with a long-handled edger which rounds both sides of the joint at once. The plates must be cleaned and oiled each time they are used else the concrete on either side may be lifted with the plate and cracked.



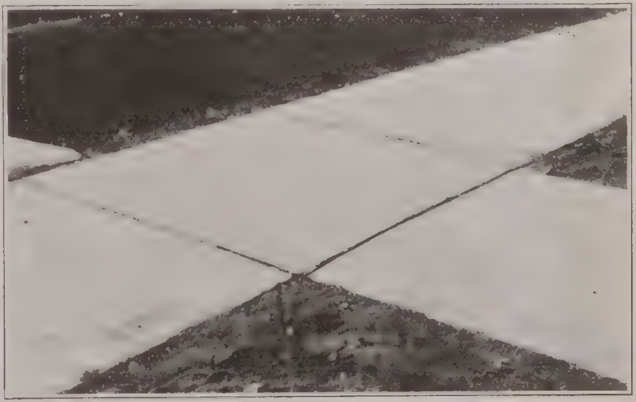
This is one of the handy division plates used.

Expansion joints of half-inch premolded bituminous materials were put in between all walks and the backs of curbs, entirely around the six-foot block forming the intersection of two walks, between the walk and all drives or private walks and at 30-foot intervals elsewhere.

Edging the expansion joints with the hand tool.

Finishing Methods

Concrete was deposited a half-inch higher than the forms and was then struck off with a hand template. This was followed with a tamp, much like the template, but provided with plow handles at each end. The surface was floated with a wooden float, again struck off with a light template, then given its final finish with a 2-ply 8-in.



Expansion joints are inserted at sidewalk intersections.

Division plates were easily pulled with the special hook.

canvas belt followed with a 10-in. canvas belt. At first only one strikeoff template was thought necessary but that left the surface too coarse-grained for a sidewalk so the second template was put on and the difficulty was remedied. The 8-in. and 10-in. belts were found more satisfactory than either the 6-in. or 12-in. widths. Along the forms the concrete was carefully spaded to eliminate any honeycomb spots. In hot weather the walk was sprinkled for four days to insure the complete hydration of the cement.

The joints were edged with this device.

The crew consisted of seven men who placed and finished the concrete and ten who dumped materials, set and pulled up forms and worked on the subgrade. The average run per ten-hour day was 1,400 lineal feet of walk; the largest day's run was 2,003 feet and the smallest 1,000.

This mode of construction is far superior to the ordinary trowel finish, as it gives a *firmer, surer, more satisfactory footing* in all seasons and all kinds of weather, and is much stronger and cheaper. In a city where there are miles of walks to build each year the more efficient large outfit can be used to the advantage of everyone concerned.

Highest Chute Tower Found on Exchequer Dam

The contracting firm of Bent Bros., Inc., of Los Angeles, have installed what is probably the highest chuting tower in the world. It is located on their Exchequer Dam contract in the Merced Irrigation District, California. This steel mast, 475 feet high, is but part of a very extensive concrete mixing and placing plant used on the project which cost the contractor $500,000 in place. This outlay does not include the cost of the gravel pit at Hopeton, which represented an outlay of another $170,000 before the work could be started.

A construction view of the recently completed dam, with the concreting plant at the base

The Exchequer Dam is the largest project of its kind in America. It is not believed that any other dam in America holds back a body of water of a greater depth. Below the dam is the concreting plant. In building this plant it was necessary to build an especially heavy trestle from the Yosemite Valley Railroad tracks to the roof of the power house, and a heavy gallows frame had to be constructed to unload and place the machinery.

At Hopeton, sixteen miles below the dam, the contractor had to install a modern gravel plant to supply not only all the aggregate for the dam and the power house, but an additional 120,000 tons of material that was needed for the construction of bridges, tunnels, and for ballast on the relocated line of the Yosemite Valley Railroad. An enormous concrete plant was required since the contract called for the placing of 200,000 cubic yards of concrete during the first year and 300,000 cubic yards within fifteen months after the signing of the contract. In order to handle the vast quantities of materials involved, the train service of the railroad had to be most carefully synchronized with the needs of the construction program. Great aid was given in this way by the officials of the railroad.

Boston Block Man Reports Interesting Test Results

John M. Simpson makes good block in East Boston, Mass. To prove it he shows a report of some tests made by Edward M. Roemer, Supervisor of Inspectors, of the Boston Building Department. According to the report, Mr. Roemer selected 12 blocks at random from a pile of 8,000 in Simpson's yard and marked them from 1 to 12. The block were of the 8 x 12 x 16 variety made on his Ideal power tampers, and advertised locally as Simpson's Waterproof Ideal Concrete Block. Mr. Roemer sent the first eight to the Boston Quincy Market Cold Storage Plant, and placed them in a warm dry room for 48 hours, and then weighed them. He next immersed them in water for 24 hours and weighed them again. Following this, the units were placed in a room at 4 degrees below zero for another 24 hours. The first four were frozen as they were, while the next four first had their cores filled with water. No. 1 showed no ill effects from this treatment, while Nos. 2 and 3 broke in two pieces, with a clean break like granite, and No. 4 showed an end crack after 18 hours.

These units and the rest of the twelve were then taken to the laboratory of the Massachusetts Institute of Technology for the compression tests. The following tabulation tells the story:

	—Weight—		——Compression——		
	Dry	Net	lb. per block	per sq. in. gross	
1	91	93	369,600	1945	Voids filled and frozen 24 hours at 4 deg. below zero. Thawed 48 hours. Cracked in freezing.
2	88	91	——	——	
3	88	90	——	——	
4	89	91	——	——	
5	89	91	316,800	1667	Immersed in water 24 hours and frozen at 4° below zero 24 hours and thawed out 48 hours.
6	91	92	321,200	1690	
7	90	92	292,600	1540	
8	90	91	352,000	1962	
9	89	—	393,800	2073	as delivered from stock.
10	89	—	387,200	2038	
11	90	—	352,000	1870	
12	90	—	389,400	2050	

Average absorption 2.09%.

Average compression blocks as delivered from stock 2008 lbs. per sq. in. gross.

Perhaps other products manufacturers could report equally interesting tests.

Reinforced Concrete Coal Pockets

Opportunity for Concretors in Building Concrete Coal Pockets — Types of Bins Used — Design — Construction Methods—Costs

By WILLIAM WREN HAY

THE design and construction of reinforced concrete coal pockets is a fertile field for engineers and for contractors in many small cities and towns. Grain dealers found and have made universal the tall, narrow, circular bin for grain storage, and coal dealers throughout the country are now making this type of storage universal in their business.

The use of silo bins for retail coal storage has increased thus largely because no other type or material can compare in first cost and ultimate cost. The use of silo forms or metal forms has contributed to this development and influenced both the cost and arrangement. Sliding, or slip forms are also used, but they require more expert operation and cannot be purchased "ready to use." There are contractors in every state owning such forms and when there are none at hand, and the storage justifies, it will often pay to buy a set and re-sell on completion.

Types of Bins

The arrangement of the silo bins may be "nested" (Fig. 1), or in a single row (Fig. 2), or elevated on heavy foundation walls with team driveway below (Fig. 3), or resting on a thick foundation mattress, with loading chutes in the bin walls (Fig. 2). For facility in using the forms the bins are not contacted in their vertical height when built in a single row; when nested they may be contacted, but are usually set apart about 3 ft., and after pouring are joined by short concrete walls or by timber walls. A shallow notch is left for the cross-walls, V-shaped for concrete and U-shaped for crib (2 x 4's spiked flat) cross walls. Silo bins are frequently divided in this way into two or four pockets for the storage of various market sizes.

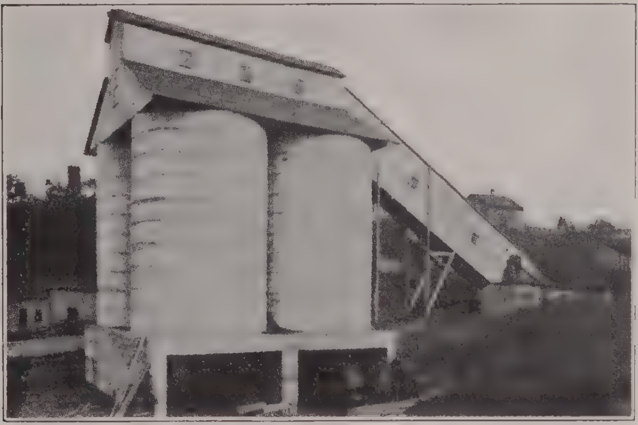


Fig. 1

Until recently, silos erected for coal storage were tall, comparatively narrow, bins patterned after grain bins, but there has been a tendency to reduce the height on account of the elevating machinery required and because additional storage has been secured by not hoppering the bottoms. The usual bin will store from 200 to 250 tons, requiring a bin 30 ft. high when 18 ft. to 20 ft. in diameter, or 40 ft. high for diameters of 16 ft. to 18 ft. From two to six or more silos may be built in a group, 14 ft. to 22 ft. in diameter, sometimes up to 60 ft. high, but rarely over 40 ft. The walls are made 6 in. thick for diameters up to 16 ft. and 7 in. thick for diameters of 17 ft. and up to 22 ft.

Design

Circular bin walls are designed as for grain pressures when they are very deep compared to their height, but unless the designer is familiar with this work and has tables computed, it is a very laborious process. The writer recommends that (for coal) the usual formula for shallow bins,

$$p = w.h. \tan^2 (45^\circ - \frac{a}{2}) \qquad (1)$$

be used until a depth of $\frac{h}{D} = 2$ is reached, after which

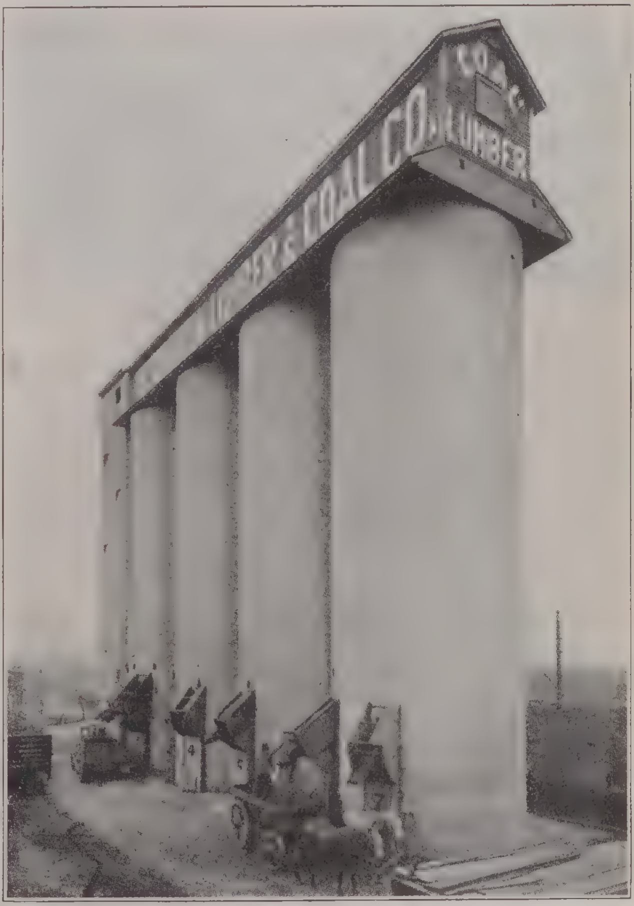


Fig. 2

Figures 1, 2, 3, courtesy Gifford-Wood Co.

the horizontal pressures are assumed uniform and equal to
20.D for anthracite coal, and
27.D for bituminous coal.

The relation of these values is shown graphically by Fig. 5, where $p = \frac{w}{4f} D$ is the maximum horizontal pressure by the formula for pressures due to granular materials in deep, narrow, silos.[3] This method gives somewhat larger pressures than theoretically necessary in the upper part of the bin, but it is on the safe side, and practical. If the unit stress in steel for reinforcing against this bursting is taken at 16,000 lbs. per sq. in., the area computed by the above method will be approximately equal to that obtained by the use of the theoretical pressures and the unit stress of only 12,000 lbs. customarily used to allow for the surges that occur in all deep bins when emptying.

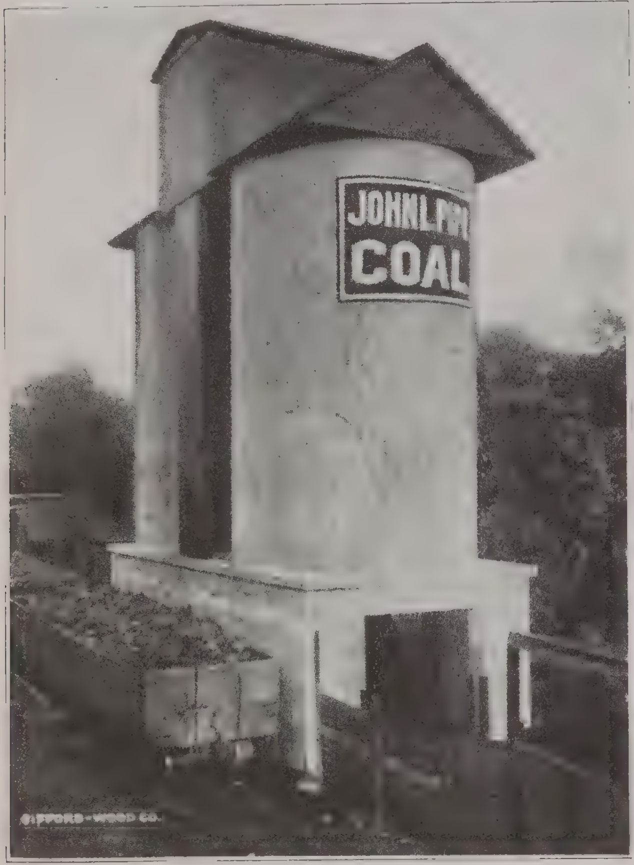


Fig. 3

Reinforcing steel may be either round rods or flats—rounds are all of the same diameter with varying spacing; flats are all of the same width and spacing of 12 in., making a convenient unit to place and easily handled on account of the shape and spacing.

The design of the bin bottoms and means of emptying depends on the arrangement. When the bins are all elevated over the driveway, the supporting walls should be placed to catch as great a length of wall above as consistent with the clear driveway. A good plan is to start the forms at grade, blocking off and forming an opening for the driveway. Place the bin-bottom slab at the required height, and then re-set the forms on this slab and commence the actual bin walls. Bin bottom slabs are

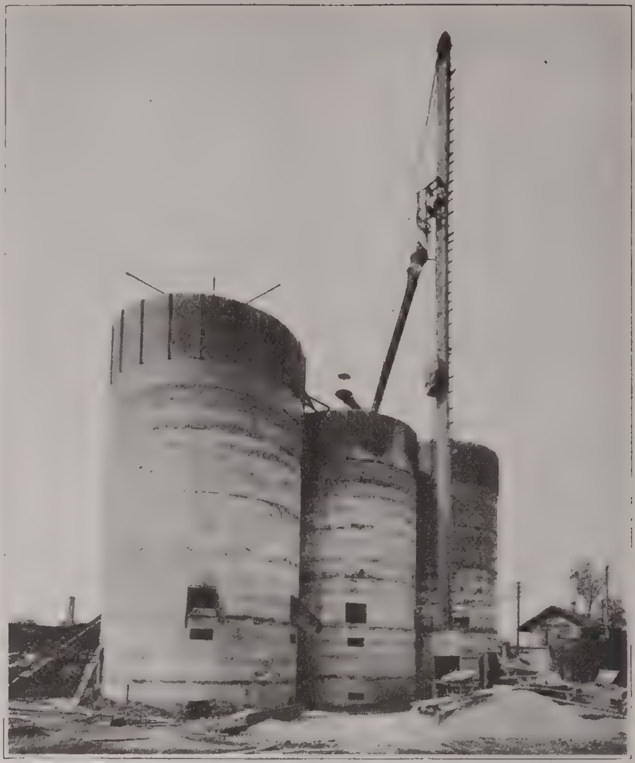


Fig. 4

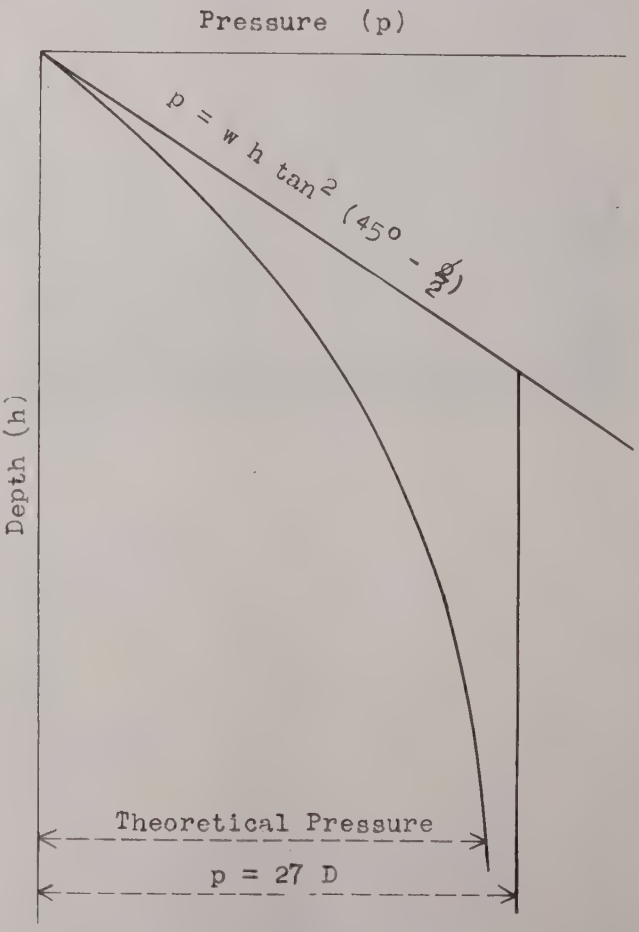


Figure 5.

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[3] p = bursting (horizontal) pressure; w = weight of coal per cu. ft.; a = natural angle of repose (27° for hard coal, 35° for soft coal); D = inside diameter of bin, in feet; f = coefficient of friction on concrete (0.7 for hard coal, 0.5 for soft coal).

generally 10 in. thick, properly reinforced to carry the dead weight of the slab and fill for hoppering, and the maximum bottom pressure due to the coal, equal to

50.D for anthracite coal, and
100.D for bituminous coal.

When the ratio of height to diameter is less than 2, the bin bottom slab must be designed for the full weight of coal. Bins drawn off from the bottom do not need to be hoppered, nor is it customary, and there will be a certain amount of "dead" space from which the coal cannot be drawn. It can always be shoveled out and forms a small reserve storage. The driveways under bins should have a minimum headroom of not less than 10 ft. 6 in. clear.

Loading from Bins

When there is no driveway below and coal is drawn off at the side by loading chutes, the bin walls start at grade, resting on a heavy concrete mattress at least 12 in. thick and provided with a scour wall 12 in. deeper all around, unless the foundations are much below the surface. The lower part of such bins is then filled with clay, brick bats, cinders, or lean concrete, to a height of 10 to 13 ft. above the roadway, and are hoppered from the draw-off spout at this level if desired. "Live" storage should be figured from about 13 ft. above the driveway, as this is the lowest point that is useful for loading. If hoppered, the slopes should be paved either with a concrete slab properly reinforced or by brick laid on edge and plastered with cement mortar. The slope of the hopper should not be less than 35 deg. and preferably 45 deg. Side-loading chutes differ according as they are for hard or soft coal—for anthracite the opening should be 16 in. by 12 in., or 16 in. by 16 in., with a wire mesh screen. For bituminous, the opening is 24 in. by 30 in, with a bar screen. Gates are of the radial cut-off type of heavy plate and angle construction. In the folding steel wagon chute is set the screen which removes dust and undersizes and returns them to a wooden pocket below having a clean-out door. If no fill or hopper is made in the bottom of bins, a door 12 in. by 16 in. should be set in the bin wall at the bottom to permit cleaning out.

The cupolas over the bin tops should be concrete, or cement plaster on metal lath, but too often they are of wooden construction and have been the cause of many fire losses. They need only be about 7 ft. 6 in. from the top of the bin to the roof line, as the top run of the filling conveyor is usually only 6 ft. above the bin tops. An 18-in. manhole should be provided to each bin when the bin tops are covered.

Bins of Precast Units

Concrete coal pockets having walls made of precast concrete staves and concrete blocks are erected in all parts of the country. While these units have their disadvantages in that they should not be partitioned into bins, and are limited as to the height advisable, yet they are often cheaper to construct, and when built by experienced labor certainly serve the purpose with safety and economy. Cement staves are made with concave and convex edges so that they will fit close together, and are held in place by steel hoops much like wooden stave tanks are bound together. Concrete block are made with radial ends to permit laying the curved wall and a groove is cast in the top to receive steel hoops for resisting the bursting pressures, the bed of mortar for the following course filling the groove and embedding the steel.

Filling the Bins

The equipment used for filling the bins is either a continuous chain-and-bucket elevator conveyor running over the bin tops or spouting to them, requiring a "coal ladder" for lowering the coal to the bottom in a steady stream, or else a large bottom-dump bucket which is raised to a monorail and automatically dumped on contact with the coal when lowered into the bin. This equipment should unload and elevate a car an hour and will handle from 10,000 to 12,000 tons per year at a cost of about ten cents or less per ton.

Advantages and Cost

The circular bin provides the most storage for a given wall surface on a given plot of ground, for the least materials and the smallest cost. (Square or rectangular bins up to 15 feet across and of small capacity are, however, more economical for small bins). Considerable yard space is saved because a piece of land the size of a small city lot, 50 by 125 ft., providing it has side-track service, is large enough for most requirements.

The capital cost of a retail coal storage plant of the types considered is now $14 to $18 per ton of 40 cu. ft. storage capacity. A yard saving of at least 35 cents per ton of coal handled between car and truck, as compared to hand labor, is a conservative estimated saving. The yearly cost, including fixed charges, maintenance and operation expenses, taxes and insurance, and interest on the investment in stored coal, is about 75 cents per ton of coal handled.

W. D. M. Allan Heads Products Bureau of Portland Cement Association

Announcement has been made that W. D. M. Allan has been appointed manager of the Cement Products Bureau of the Portland Cement Association, effective November 1. He succeeds A. J. R. Curtis, who becomes assistant to the General Manager of the Association on the same date. Mr. Allan, who is widely known in the building and cement products field, has been engaged in the promotion of concrete products for the past seven years. Formerly he was a member of the Cement Products Bureau Staff, but more recently he served as office manager of the Illinois District Office of the Association.

The Cement Products Bureau handles one of the most important divisions of Association activities, which include concrete masonry houses and structures of all kinds, stucco, lighting standards, cast stone, roofing tile, as well as concrete around the home and farm uses.

Concrete masonry structures in particular are forming a major part of the work. Each year has seen a growing interest in concrete masonry homes and the number of concrete products being manufactured have yearly been setting higher and higher records.

Washington, D. C.—The strength of portland cement drain tile may be increased materially while its quality of absorbing water is decreased by placing the tile in a bath of molten sulphur until completely impregnated, investigation by the Bureau of Standards discloses. In some cases, however, such treating will not prevent deterioration of the tile. For instance, a number of these tile placed in alkali soil in Colorado decomposed almost completely in two years, during which time tile unimpregnated with sulphur also decomposed. It is evident, therefore, that such treatment does not render portland cement drain tile immune to sulphate salts.

Here and There

Some Random Notes on Visits with Concretors in the Field

ONE of the finest ways for us to learn about your problems and about your successes is, of course, for us to come and visit you at the plant or the job or the office. But, in order to get this paper to you every month, we must spend a lot of time in our office. Even then our close contact with the field is not lost because there are always visitors who tell us about things of interest to concretors.

* * *

THE other day an engineer who is in charge of the construction of a very important concrete structure came into see us. He has a very unusual job—one in which the strength for which the concrete was designed must be developed in the time allowed. So he is very particular about his test cylinders and watches the results carefully.

He found out some interesting things about the effect of temperature on the speed of hardening of concrete. Even before the weather reached the stage where precautions against freezing were necessary, he found that there was a direct ratio between temperature and speed of attaining strength. He kept temperature records and tested cylinders frequently and collected a lot of interesting data. We hope to be able to pass this on to you in some future issue.

* * *

NOT so long ago we had two visitors from Europe—one, an authority on cement manufacture and the other a city engineer. It seems that over there the city engineer designs bridges also as well as laying out sewer systems and streets. He told us about a bridge job that he designed and built in an important German city.

He described the use of some unusual sliding supports in both arch and slab bridges. They used railroad rails face to face, one set in the slab or arch and the other in the abutment or pier. As the concrete expands or contracts, the superstructure slides on the rails and all expansion or contraction is taken care of.

* * *

LOST time accidents was the subject brought up by a construction superintendent. His firm, working on a country-wide basis, is running a safety contest between the crews on the various jobs. So seriously have the men taken to the work that one of the superintendents has cut down lost time accidents on the job to the point where they are practically a thing of the past.

* * *

THIS same super, finding himself on a job where the bid was pretty low, took advantage of a bonus offer made by his firm and has agreed to split his bonus with the men if they can beat the job schedule. In spite of the current labor policy, the foreman sets a daily task for each man and the spirit of sportsmanship as well as the incentive of the bonus make things move.

* * *

THE use of high alumina cements is a subject upon which many concretors would like to have more authoritative information. We had a visitor who was an authority on that subject. He had a lot of material on just how to use this cement and the best part of it was that he promised to get it into shape so that we could pass it on to you.

SPEAKING of visitors from foreign countries. Just the other day, in came a Scotchman from Glasgow. He wanted to learn more about cast stone manufacture and was planning on visiting some American plants. And he wasn't a novice at the business, either. He has a dandy plant in Scotland and has done some church jobs that many an American cast stone manufacturer would be proud of.

* * *

TWO men from the wild and woolly west came into the office one day not long ago. They were the big guys in a wonderfully successful cast stone manufacturing organization. They have several plants in various parts of the West and are not yet through expanding. They consider the manufacture of cast stone a scientific problem—not merely a hit or miss method and they go on the policy that a quality product will get there *if it is sold.*

The manufacture of the cast stone is one problem. The selling of it is another. Both are real jobs requiring the best effort that can be put forth. With such a policy, they cannot help but continue to make good.

* * *

DID you ever wonder what actually happens when concrete is exposed to air and water year in and year out? It is hard to find any material that does not rust or weather or undergo some change when it is exposed to the elements. Is concrete exempt from this action?

We had a visitor who said that it was not. And he based his statement on researches that extended over a good many years. He had stacks of data to prove his point. Of course, there are many equally good engineers who disagree with him and the question is far from being settled. That is a subject that concretors ought to think about.

* * *

THERE is an interesting race on in one of our large cities. Two contractors, working side by side, found themselves facing cold weather with the jobs just about started. One of the jobs is a steel building, the other a reinforced concrete building. They declared a race. The steel man had a two days' start and things were going at a fine rate. But the concrete man was not caught napping. He established a form shop out on the edge of town and prefabricated his forms into handy units.

When these forms got to the job they were rushed into place, the shores were run up, everything was clamped tight and the work went ahead. The upshot was that the concrete man soon passed his rival and there are rumors that the steel job is going to be changed to concrete on the upper stories! Incidentally, that stunt of pre-fabricating the forms is one that might come in handy to some other concretors.

* * *

ALL sorts of men come to the office of a paper like ours. Some have some queer propositions and one fellow came in asking for railroad fare to his home town on the strength of his claim that one time he had worked with a concrete gang. But most of our visitors have some real suggestions to offer and have had some experience or learned some things that are helpful to their fellow concretors. It is one more way in which close contact with the field is maintained so that our pages can be of greater value to you.

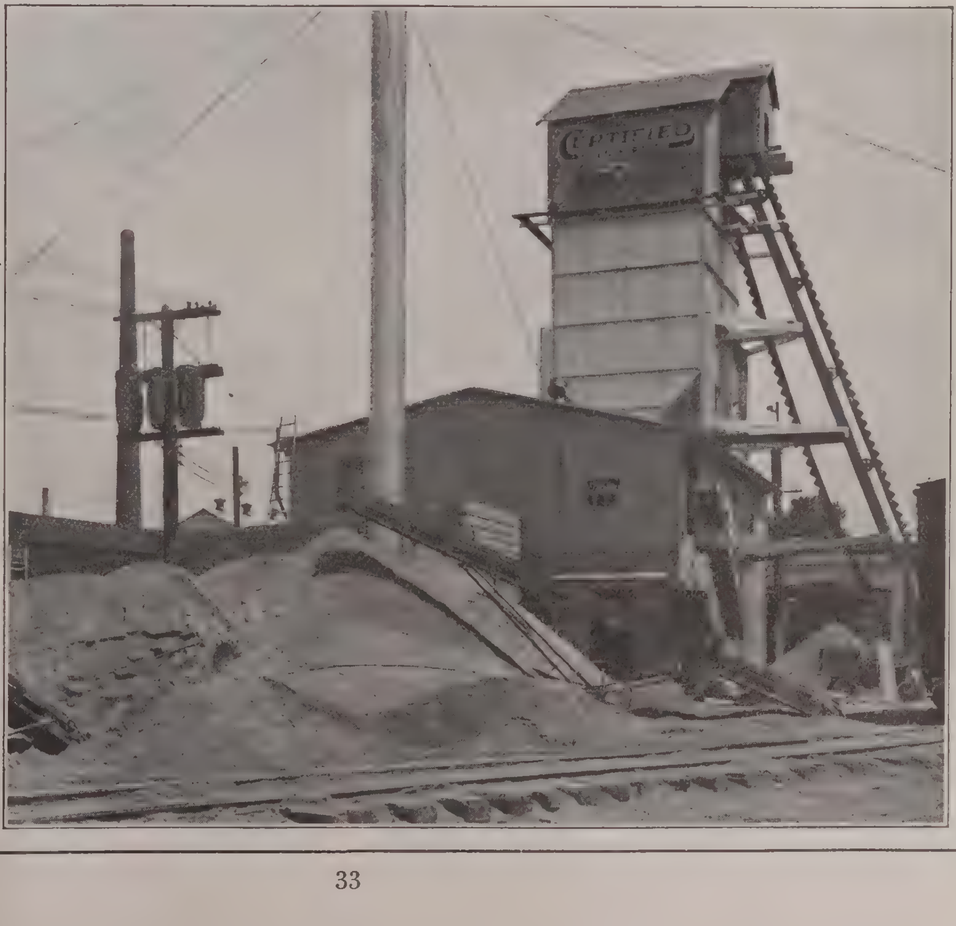
A Material Dealer Makes Block

Sound Business Sense Dictated the Policies Adopted by George F. Perry & Sons When They Went Into the Products Industry — Adding Own Block to Line of Building Materials—a Trademarked Product—Can Fill Any Order—the Plant They Installed

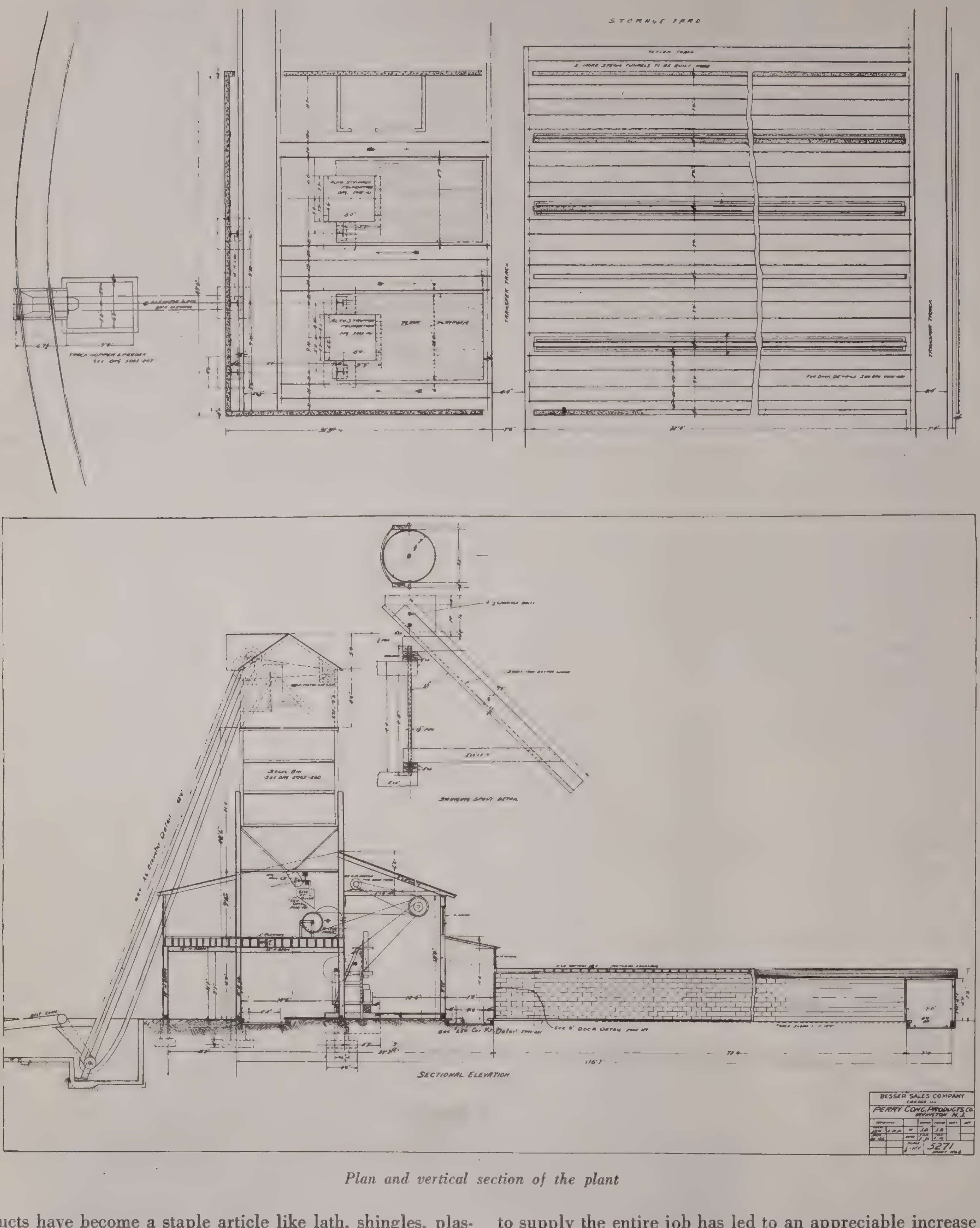
WHEN the material dealer makes concrete block and tile to add to his line of construction materials he does it according to the dictates of sound business policy. With him it is a business that must show a certain profit or go the way of unprofitable ventures. When the dealer happens to be an outstanding success in the sales of other materials, his ideas on the products business certainly are worth attention. Big business begets a breadth of vision and a careful calculation of future conditions that are not so often brought out where the volume of business is small. We present herein an account of the business policies and manufacturing methods used by George F. Perry & Sons, material dealers.—The Editors.

OUTSTANDING among the successful material dealers of the New York area is the firm of George F. Perry & Sons, Incorporated, located at Irvington, N. J. In addition to being one of the oldest and most successful material firms in that territory, they are among the largest manufacturers of concrete products in the United States. They had an idea that manufacturing and selling concrete products was a natural part of the building material business, and the correctness of their estimate of the possibilities of the products industry is attested to by the fact that they have recently completed the construction of a new and modern plant that is worthy of study by any products manufacturer.

The demand for concrete products had so grown, due to the labor-saving involved in the use of hollow masonry units, and to the economy of the material itself, that they felt justified in going into the business on a big scale. The growth of the industry during the past ten years has demonstrated the structural worth of concrete building products as a masonry material. This firm then naturally saw that the introductory stage of such materials had long since passed, and now consider that concrete prod-



General view of plant showing aggregate bin, bucket elevator, belt conveyor to cement storage, and pile of sand for team delivery to local jobs



Plan and vertical section of the plant

ucts have become a staple article like lath, shingles, plaster, and other widely used materials.

A Desired Material

Their experience has been that the ability to furnish block or tile in any quantity to meet the trade conditions assures them a steady sale of their standard materials, such as mortar, sand, cement, plaster, plaster board, and other items ordinarily carried by a material dealer. The ability to supply the entire job has led to an appreciable increase in the annual volume of business, together with a reduced sales expense, since many a contractor has been glad to deal with any firm in a position to give him the required service on every material that goes into the job. The addition of concrete products to their line gave them an opportunity to meet the needs of a market that calls for one or two million units a year, on which they found the sales costs low and the profit attractive.

Naturally a firm like this would adopt business methods that would prove effective.

Since the firm handles a line that includes a number of nationally advertised materials it was but natural that their attention should be given to the trade-marking of their concrete products. The policy of a quality product, duly advertised, and identified by a distinctive brand name, was therefore adopted.

Meet the Demand

Since service has always been the keynote of the business, the plant had to be arranged so that any sort of block or tile could be furnished depending upon the ideas of the customer. No matter whether it is two core or three core units that that customer wants, the machines can produce them in volume. A large stock of units is kept on hand in the yard in order that no green blocks will ever be shipped to the job. Since the block and tile, like their other materials, are sold on a guaranteed basis, the trade name "Certified" was adopted to distinguish their units from others on the local market. While the investment required to carry stocks of the character shown requires a considerable amount of working capital, they feel that the results, in the dependable nature of the product, more than justify the initial investment.

This closeup shows the undertrack reciprocating feeder, operated from tail shaft of bucket elevator, delivering aggregates to the bucket elevator from the track hopper

To turn out a vast quantity of well made units at a cost that will yield the profits desired, it proved necessary to install a modern plant designed for the required production. The new plant now being used by this concern indeed proves interesting. It was designed and equipped by the Besser Sales Company, of Chicago, and reveals the present ideas on plant design held by that concern.

Aggregate Handling

The aggregates are delivered by rail in bottom dump cars on the company's own siding. The sand and limestone screenings are dumped into a track hopper, and then conveyed to the boot of a bucket elevator by an undertrack reciprocating feeder. The aggregates are then lifted by the bucket elevator to the top of a steel bin which is divided into two compartments—one for each material. The cement is unloaded with the aid of a belt conveyor, directly from the box car to the cement storage room on the second floor of the plant building, on which floor are located the two 21 cubic foot batch mixers that serve the machines. A traveling bucket is suspended from an overhead monorail, and this bucket receives aggregates from the bins, automatically proportions the batch, and delivers each batch to either mixer. This bucket has a capacity of 21 cubic feet. The proportioning is carefully controlled in order that a uniform product may be secured. Heated water is supplied for the batch from a series of water barrels into which exhaust steam is run. This water is carefully measured in order that the correct water-cement ratio may be maintained.

Here are the two combination automatic stripper block and tile machines. The offbearer is taking away the finished block while the machine turns out the next one. The rack cars are loaded alongside the machine, making the shortest possible travel. Two men operate a machine, turning out six pallets per minute

The two mixers, located on the balcony, or second floor, feed directly into the supply hoppers of the machines. The traveling batcher is shown directly over the left hand mixer. It brings aggregates to both mixers from the central bin discharge gate

Each mixer is located over the receiving hopper of each of the two machines. These two automatic stripper machines are located on the ground floor. They have a capacity of one block or two tile in one operation, and turn out six pallets a minute. Both machines are equipped so that either two- or three-core units, or fractional units, may be produced without losing much time for the change.

Handling the Block

The units are placed on rack cars as fast as they are made, and these rack cars transport the products to the kiln, and from the kiln to the yard. Tracks are so arranged that materials move the shortest possible distance from machine to kiln and from kiln to yard, and so that piling in the yard will incur no long carries by hand.

Two departments not always found in the block plant give an indication of the thorough way in which this plant is run. A completely equipped machine shop has been installed in order that minor repairs on plant equipment, yard equipment, and delivery equipment may be quickly done. This minimizes delays due to broken equipment, and is said to reduce the cost of repairs. Another point is that the problem of the disposal of broken units has here been solved in an interesting way. A small crusher has been installed just outside the building, in a little shelter of its own, and this crusher is used to reduce the broken units to aggregate size. A few minutes work now and then turns plant waste into good usable aggregates at a low cost. Larger stones delivered with the aggregates are treated in the same way.

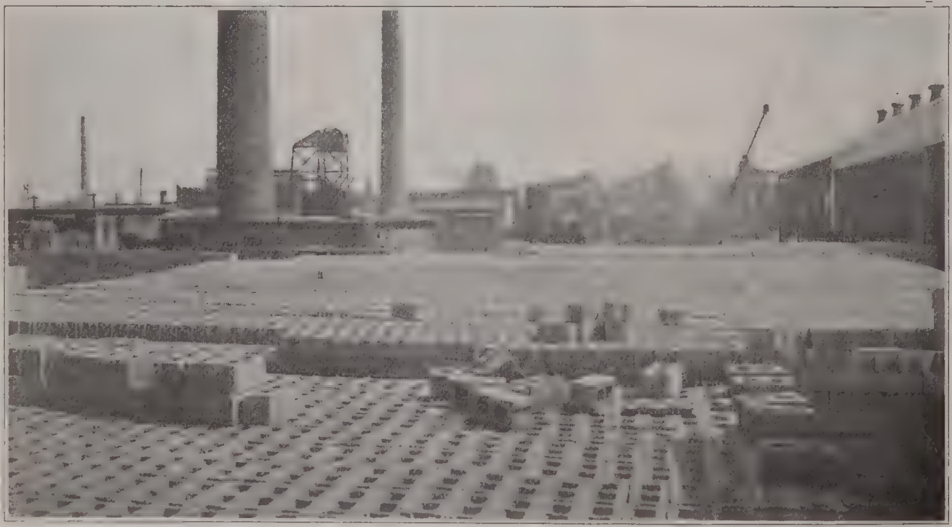
Loading green block into the kiln. Curing rooms to the rear are closed and steam is on. Hinged deck one-man rack cars hold 72 block

They Advertise

An outstanding feature of the plant is the sign painted on the side of the aggregate bin. This sign shows the trademark and the name of the company, and displays pictorially the slogan, "The Block of Gibraltar," a slogan adapted to giving the purchaser the desirable idea that "Certified" products are more than amply strong to do their work. This sign is illuminated at night by means of a battery of floodlights mounted on the roof.

This machine shop enables quick repairs for all equipment. It contains a woodworking saw, a lathe, drill press, grinding machinery, and other equipment

Thus a number of important points are featured in this plant where the producer has gone into the concrete products industry on a business basis. First, a good looking and efficient plant has been installed where the user can see a good product produced at a reasonable cost in a real factory. Second, a plentiful supply of well seasoned units in the yard bespeaks an ability to supply any requirements at a moment's notice. Third, the plant is well advertised by the neatness of the plant and of the yard, as well as by the prominent sign on the aggregate bins. Fourth, the prominent use of labor saving devices and a good plant layout provides operating efficiency. And fifth, the sale of the units as part of a complete line of building materials guarantees a turnover at a low sales cost.



Here is the part of the yard devoted to the storage of block. In another portion of the yard is a great stock of tile

The Constitution of Portland Cement Clinker*

Part VI of a Digest of the Literature on This Subject—Studies of the Mechanism of Clinker Formation Through the Agency of Heat Reactions—A Study of Heat Requirements and Sequence of Reactions Taking Place During the Burning Period—Early Theories—Tschernobaeff's Researches and Conclusions—The Heat Curve Method — Other Investigations — Summary of Present Reliable Views on the Reactions of Clinker Formation

By R. H. BOGUE

THE work of collecting and assembling all the studies already made on the constitution of portland cement clinker for the purpose of preparing this digest, involved the compilation and study of many phases of research on this important subject.

PREVIOUS chapters have described the painstaking efforts of scientists to solve the problems from many different angles. With investigators working on the same general subject from varying viewpoints and in various locations at different times, masses of material have resulted. In this series of articles, this material has been sorted and classified and the more important findings have been grouped under separate headings. In the previous chapter the efforts to apply structural formulas to cement compounds were described.

VERY few studies have been made directed primarily at an understanding of the reactions and sequence of reactions that take place during the burning process in cement manufacture. Complete researches on this subject have never been undertaken, but some independent partial studies have been made. Investigators have tried several methods of determining the heats of formation of the compounds found in portland cement clinker.

THE studies of these scientists, their methods of experimentation and their findings are presented in this chapter on "Thermal Reactions of Clinker Formation."

Part VI.—Thermal Reactions of Clinker Formation

VERY few studies have been directed primarily at an understanding of the mechanism of clinker formation through the agency of heat reactions. One of the outstanding difficulties to such an investigation has been the lack of positive information on the exact nature of the raw materials and of the finished product.

There are obviously several methods available from which approximations may be obtained, but the possible methods which consider all factors are very limited. If the whole purpose of the problem be to figure heat requirements and kiln efficiencies, it should suffice to start with cement raw materials and measure by some means the heat reactions of clinker formation. But if the object be to gain a more intimate understanding of the exact nature and sequence of the reactions taking place during the burning period, then pure compounds must first be employed. Nor is it sufficient then to proportion these in the ratio found in cements, and heat to fusion, if we are to learn the nature of each reaction. For the number of independent and dependent reactions is so great that an intelligent interpretation of data so obtained would be difficult. Indeed, to arrive at a complete knowledge of these reactions would require independent studies on the heats of formations of each of the binary and, if they exist, ternary compounds present in the clinker. To make the matter more complicated, it should be remembered that the heats of crystallization may be opposite in sign to the heats of formation, and yet dependent on a saturated solution in the molten magma. To explain the entire process adequately, each of these factors must be considered, both independently and in conjunction with each other. Such a research has never been undertaken.

Early Theories

The methods that have been employed, while necessarily far from conclusive, may be regarded as very valuable

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*Paper No. 3 of the Portland Cement Association Fellowship at the Bureau of Standards.

"first approximations."

A few of the earlier writers[39] who speculated on the heats of reaction of cement and cement raw materials assumed that there was an exothermic reaction, but that it was negligible. In 1904, Richards[40] published a paper in which he attempted to calculate the thermal efficiency of a cement rotary kiln. This work was based on a number of assumptions. He used Berthelot's figures for the heats of formation of the silicates and the aluminates, deriving 591 gram calories per gram for CaO and 827 gram calories per gram for MgO, liberated as a result of these reactions. No account was taken of the manner of combination of the silica, but the lime and magnesia were assumed to be present in the raw mixture entirely as carbonates. His calculations on a cement containing

	Per Cent
SiO_2	21.27
Al_2O_3	6.42
Fe_2O_3	3.18
CaO	66.70
Mgo	2.43

indicate a very large exothermic reaction, and Richards affirmed that when the raw materials are heated to about 1000° C.

> They ignite and combine, like a pile of anthracite coal when heated to redness, and become, by their own heat of chemical reaction, much hotter than the temperature to which the gases heated them.

These results were vigorously attacked by Le Chatelier[41] on the basis that the heats of combination of silica and alumina with lime were not accurately known. Le Chatelier calculated values for the exothermic reaction, and found them to be about half those obtained by Richards.

Shortly after this, Soper[42] published a report on the thermal efficiency of a kiln at Iola, Kansas, in which he made use of Richards' values for the exothermic reaction.

Tschernobaeff's Studies

A very important contribution on the heats of formation of the silicates was made by D. Tschernobaeff[43] in 1905 and rechecked in 1911. This work represents the first serious effort to determine the heats of formation of the silicates of cement and of cement clinker by direct methods. The procedure employed consisted in mixing the silica with charcoal and chalk in an oxygen bomb calorimeter. The heat of combustion of the charcoal caused the combination of the silica and lime. This procedure was checked by burning (1) the raw materials with silica and (2) the clinker obtained from these raw materials with silica, and assuming that "the difference of the heat values of the two reactions must be an expression of the heat values of the reaction which takes place on converting the raw material to clinker." Results by the above methods checked very well, and Tschernobaeff concluded:

(1) Cement formation is attended by an important evolution of heat, the heat value of the reaction per gram of calcium carbonate becoming smaller as the amount of the basic constituents of the raw material increases.

(2) For a cement of the usual composition resulting from a raw material containing about 75 per cent calcium carbonate, the value of this exothermic reaction is 115 to 118 gram calories per gram of calcium carbonate in the raw material. We calculate from this that the total heat of formation of cement under works conditions (i. e., under constant pressure) is $+115 - 435 = -320$ gram calories per gram of calcium carbonate in the raw mixture, this being the sum of the exothermic reaction and the heat of dissociation of calcium carbonate.

These results were later modified somewhat, but the order of magnitude was not affected.[44]

Tschernobaeff determined also the heat of dehydration of clay, and gives the value as 112 gram calories per gram, but J. W. Mellor and A. D. Holdcroft[45] found, by a calculation from heating curves, a value of only 41.9 gram calories per gram. The latter authors deduce from their heating curves that the following reactions take place on heating kaolin:

(1) Endothermic decomposition near 500°, probably corresponding with the formation of free SiO_2, Al_2O_3 and H_2O.

(2) An exothermic reaction near 800°, probably due to a polymerization of the Al_2O_3.

(3) An exothermic change near 1200° probably corresponding with a recombination of the silica and alumina.

The findings of Mellor and Holdcroft have been confirmed by S. Satoh.[46]

Dorman and Helbig

O. Dormann[47] and Helbig[48] have used Tschernobaeff's figures for calculating the heat of formation of clinker. Using 165 gram calories as the value of the heat of formation of $2CaO.SiO_2$, and 125 for $3CaO.SiO_2$, and regarding the heat of formation of $3CaO.Al_2O_3$ and the ferrites as negligible, and assuming further that the two silicates are present in equal amounts, Dormann finds for a cement assumed to contain 77.5 per cent of calcium silicates and 22.5 per cent calcium aluminates and ferrites, that the heat of formation of clinker is 112 to 114 gram calories per gram of clinker. This heat is sufficient, according to Dormann, to raise the temperature of the raw mass from 1100° to 1643° C. The latter temperature is not reached due to losses by radiation, but he finds a surface temperature on the clinker, by the use of an optical pyrometer, of 1550°. The temperature of 1100° is required, in Dormann's opinion, to release the last traces of carbon dioxide and start the sintering action. Once started, this proceeds by itself, at increasing temperatures, to completion.

Calculations made on this same principle, but using slightly different compositions, have been suggested by other authors. Coghlan[49] made calculations giving values for the heat of formation of 99 and 108 gram calories per gram of clinker, depending on the data used.

Heat Curve Method

The method of heat curves was initiated by Dittler and Jesser[50] in 1910. Dittler used an electric resistance furnace and crucibles of graphite and porcelain containing 30 to 40 grams of finely powdered portland cement raw material. Platinum-platinrhodium thermocouples were inserted in the crucible and in the furnace, protected by tubing. The furnace was heated at a uniform rate of about 30° each ten minutes. Time-temperature data were taken.

From 1100° to about 1350° the curve was found to be a straight line, but at 1350° a lag was observed which bent the curve downward. This was broken suddenly at 1430° by a sharp rise which again flattened out at about 1500°. By examining the heating process with Doelters heat microscope, it was noticed that at 1375° a pronounced sintering took place throughout the mass and, at 1425° to 1450°, a sudden crystal formation. These crystals were later identified as "alite." Dittler concludes that the elimination of carbon dioxide, and also the chemical reaction between the lime and the clay, are completed below 1100°.

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[39] W. H. Stanger and B. Blount, *Proc. Inst. Civil Eng.*, *145* (1901), 44.
S. B. Newberry, *Cement Eng. News*, 1901.
C. Naske, *Tonind. Ztg.*, *27* (1903), 1733.

[40] J. W. Richards, *J. Am. Chem. Soc.*, *26* (1904), 80.

[41] H. Le Chatelier, *Le Ciment*, *10* (1905), 12.

[42] E. C. Soper, *Eng. News*, *54* (1905), 664.

[43] D. Tschernobaeff, *Memoires*, *2* (1905), 729; *Z. angew Chem.*, *24* (1911), 337; *Cf.* Pamphlet *3*, British Portland Cement Research Assoc. 1923.

[44] Tschernobaeff, *Z. angew. Chem.*, *24* (1911), 337. Tschernobaeff and Wologdine, *Compt. rend.*, *154* (1912), 206.

[45] J. W. Mellor and A. D. Holdcroft, "Collected Papers," Vol. 1, p. 277 (London, 1914).

[46] S. Satoh, *J. Am. Ceram. Soc.*, *4* (1921), 182.

[47] O. Dormann, *Tonind. Ztg.*, *38* (1914), 150; 405; 1741.

[48] Helbig, *Tonind. Ztg.*, *38* (1914), 1236.

[49] R. R. Coghlan, *Concrete* (Mill Section), *16* (1920), 39.

[50] E. Dittler and L. Jesser, *Zent. Chem. Anal. hydr. Zemente* (1910), 72.

The clinkering of the incompletely burnt material commences with endothermic melt formation which suddenly changes into a distinct exothermic reaction coinciding with the predominant period of crystal formation.

While this method does not permit of a measurement of the amount of heat involved, Dittler calculated that the latter is not large.

The National Physical Laboratory of Great Britain[51] studied this problem by heating curve methods, and reported an indication of an exothermic reaction between 1100° and 1200°.

Janecke[52] observed a sudden evolution of heat at the point of 1381° which he believed to be due to the formation of a ternary compound, $8CaO.Al_2O_32SiO_2$.

Endell[53] found an endothermic reaction at 930° corresponding probably to the evolution of carbon dioxide from the limestone, and an exothermic reaction at 1200°.

Jesser's Method

Another method was introduced by Jesser, in 1910, based on the heats of solution of raw materials and of clinker, respectively, in hydrochloric acid. By measuring the difference in the heats evolved in solution, Jesser concluded that the conversion of slurry, from which the carbon dioxide already had been expelled, into clinker was attended with a slight absorption of heat, that is, was endothermic. He says:

"On considering that, on cooling, the plastic clinker solidifies in the crystalline form, while in the unburnt mass there is no fused phase present, we see that more heat will be given up on cooling the clinker than on cooling the unclinkered mass. It follows that the addition of heat will be necessary to convert the unburnt mass into clinker, and the reaction of clinkering is endothermic."

Nacken[54] believed that the method used by Jesser was correct in principle but he could not agree with Jesser that the essential reaction of clinker formation was endothermic. Nacken accordingly made a study of the reactions. He used a calorimeter consisting of a platinum beaker immersed in a copper vessel, the whole set in a thermostatically controlled bath. In the beaker he placed (a) a sample of powdered raw mixture which had been heated to 900° to drive off carbon dioxide and water, and (b) a sample of the same composition which had been heated to various higher temperatures so that combination had been partially or completely effected. A mixture of hydrochloric and hydrofluoric acids was added to dissolve the powder completely, and the rise in temperature of the solvent noted with a Beckman thermometer, graduated to 0.01°. The difference in the heats of solution was taken as the heat of combination of the lime with the silica and alumina.

Nacken found that an exothermic reaction took place soon after the removal of the carbon dioxide, that is, at about 1000°, and that further heating to incipient fusion, or harder burning, "only gives a cement good mechanical properties, but is not necessary to the formation of clinker mineral."

Comparisons

By comparing these data with those obtained using a mechanical mixture of oxides of the same composition, Nacken calculated the exothermic reaction to be 100 gram calories per gram of clinker. From this value the increase in temperature of the clinker due to the exothermic reaction is calculated to be about 25°.

In addition to the researches above mentioned, Martin and Cooper[55] have tabulated several further sources of exothermic reaction as follows:

1. Combustion of adventitious fuel, carbonatious matter present.
2. Oxidation of ferrous compounds.
3. Oxidation of sulfides.
4. Combination of oxidized sulfur with lime.

To sum up the experimental work on the value of the exothermic reaction, the following table is presented:

Heat evolved during the exothermic reaction of clinker formation

Authority	Date	Gram calories per gram clinker
J. W. Richards	1904	414
H. Le Chatelier	1905	186
E. C. Soper	1905	159
D. Tschernobaeff	1911	134
O. Dormann	1914	113
R. Coghlan	1920	99
R. Nacken	1922	100

In terms of coal value, these reactions are found by Martin and Cooper to be equivalent to from 5.92 to 1.43 tons of "standard coal," (12,600 B.t.u. per lb.), per 100 tons of clinker.

Hendrickx' Experiments

A very interesting discussion of the reactions of clinker formation has been contributed by Hendrickx.[31] He says:

> "Clinker formation is not a phenomenon, it is a process. It is not solely a chemical combination, and the heat phenomena noted are not exclusively the offspring of thermochemical reactions. Simultaneously or successively there are produced a series of phenomena, chemical and physical, endothermic and exothermic, which are superposed and of which the resultant heat transfer may be positive or negative, determined perhaps by the conditions of the experiment."

Hendrickx urges that the course of clinker formation, that is, the *velocity of succession* or the *degree of simultaneity* of the several phenomena, or reactions which constitute them, is infinitely variable depending on the molecular homogeneity of the mix, its content of quartzose silica, the proportion of flux, the temperature of the kiln, etc. From this it follows that

> The resultant heat transfer of all of the reactions taken together, which theoretically should be constant for a mix of a given composition, is, in practice, a value not only variable but extremely difficult to establish experimentally because of the complexity and the variability of its factors.

Hendrickx separates the process of clinker formation into three groups:

> The first takes place at increasing temperatures.
> The second takes place at constant temperatures.
> The third takes place at decreasing temperatures.

Each of these groups contains a series of phenomena unfolding themselves successively under ideal conditions. But in practice the reactions superpose on each other because of the imperfect homogeneity of the mix and the irregularity in the heating.

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[51] W. Gilbert, *Arch.* British Portland Cement Research Assoc., R *176* (1915), 60; *R103* (1915), W. G. 65.

[52] E. Janecke, *Z. anorg. Chem.*, *89* (1914), 355.

[53] K. Endell, *Zement*, *10* (1921), 201.

[54] R. Nacken, *Zement*, *11* (1922), 245; 257.

[55] G. Martin and W. Cooper, British Portland Cement Research Assoc., *Pamphlet 3*, (1923).

[31] Jean Hendrickx, "Cement of High Strength" *Chemie & Industrie 8* (1922) 296. "The Manufacture of Artificial Portland Cement," Paris, 1922.

The first phase, which takes place at rising temperatures, consists of combinations of iron oxide, of alumina, and of ingredients more active than silica, with the lime, in proportions that are most variable, dependent on chance contact and the fineness of the particles.

The second phase begins as soon as any flux has become liquefied. During this period the chemical reactions are completed through diffusion made possible by the flux. The quartzose silica is assimilated, and all of the lime combinations are brought to the maximum basicity. Following this, the constituents are dissolved in each other, the more refractory in the more fusible, forming supersaturated solutions.

The third phase accomplishes the crystallization of alite during the cooling process, and finally the crystallization of the other constituents.

The first phase is regarded as consisting partly of exothermic and partly of endothermic reactions. The fusion of the flux and solution of alite in the second phase are believed by Hendrickx to be endothermic, while the crystallization taking place in the third phase is exothermic.

Hendrickx' Conclusions

Hendrickx is convinced that only the crystalline products have hydraulic properties, and that any compounds of identical composition, if amorphous, are entirely devoid of hydraulicity. The first products to enter into solution he believes to be the aluminates of lime. These, he believes, act as solvent for the silicates which later separate out as large crystals with the finer grained aluminates, imbedded in a film of glass from the flux. This film causes hydration to be very slow unless, by grinding, the crystals are fractured and separated from their glassy envelope. When very fine, grinding is practically without influence. Therefore, he states, very fine grained clinker will be very slow setting. He believes this to be the condition in so-called overburned cement. The temperature at which there is the maximum tendency of a crystallizing material to form nuclei is not the same, according to Hendrickx, but is lower, than the temperature of maximum speed of crystallization. It results on cooling, therefore, that when the number of nuclei are increasing most rapidly, the rate of crystal growth is already on the decline, and at times, as with glass, the nuclei may not grow appreciably but remain as very minute crystals. Such a clinker, according to Hendrickx, is very slow setting, as, for example, the fused cements, or may be practically worthless, as the highly overburned cements. However, if a fused cement is allowed to cool very slowly, the crystals may grow to such a size that, on grinding, they become shattered and give an instantaneous set.

Summary

The more reliable views on the reactions of clinker formation may be summarized as follows:

Exacting studies to determine directly the heats of reaction of the several constituents of portland cement or the heats of crystallization of these constituents have not been made.

Indirect determinations indicate:

1. The volatile matter of the raw mixture, especially the carbon dioxide, seems to be removed completely only at temperatures of from 1000° to 1100°. These reactions are endothermic.
2. At 1100° to 1300° combination of the lime with the silicates occurs, giving rise to an exothermic reaction. The heats of reaction of the lime with the alumina and ferric oxide are believed to be negligible.
3. A crystallization of the silicates, aluminates and ferrites takes place at various temperatures as the mass is cooled. These crystallizations are accompanied by endothermic transfers of heat.
4. The best summation value for the total exothermic reaction of clinker formation appears to be about 100-110 gram calories per gram of clinker.

Novel Method of Rapidly Breaking Old Concrete Floors

Housebreakers engaged in the demolition of a large concrete warehouse close to Southwark Bridge, London, have resorted to a novel method of speeding up a very heavy task. They improvised an extremely effective battering ram, beneath whose blows girder-bound concrete floors one foot thick were made to crack and crumble. So strong was the concrete that this method had to be resorted to in order to accomplish the task with the desired speed.

A two-ton stone, cubic in shape, was used to do the damage. This stone is raised by a crane until it is about 20 feet above the objective spot. Then there is a quick release, the huge mass crashed to the concrete floor, and a large dent, surrounded by small fractures, is the result. A second blow causes the cracked concrete to sag, but at least a third blow is required before the stone goes thudding through to the floor below, having accomplished something that would have taken a number of men hours, perhaps, to do. Often even a fourth blow is necessary, so strong is the concrete.

"As a matter of fact," said the foreman of the job in an interview, "these old concrete floors defied ordinary measures," evidence in support of the contention that concrete gains strength with age.

Building Codes and Concrete Masonry

Survey of Code Requirements for Concrete Masonry Construction in Many Cities Shows a Decided Absence of Standardization—What Is a Good Block?—What the Codes Say—Elimination of Discriminatory Provisions—A Few General Suggestions

A SHORT time ago we published an analysis of the building code requirements for reinforced concrete construction, wherein a lack of agreement on working stresses was disclosed and a certain amount of discrimination against concrete construction in a few cities was indicated. Then, too, we have told about the code work on the west coast, and have indicated, as well, a few highlights on the general code situation as concerns concrete construction.

Our code series is continued with this article dealing in detail with the factors that must be studied by the concrete products manufacturer and by the architect and contractor using his materials. Another interesting contribution to the current code movements will be offered in an early issue. —The Editors.

THE building codes of the many communities of this nation are an index and a history of the development of the concrete products industry. They record the harmful influences that have hurt the industry from within, and they record the external influences that have been brought to bear in many sections at one time or another to prevent the inevitable progress of the industry. Their provisions with regard to concrete masonry construction indicate the degree of success with which local manufacturers have solved their problems of competition with irresponsible back-yard producers and with the producers of other fireproof building materials, and their problems of overcoming normal sales resistance. The most modern codes demonstrate conclusively that concrete products produced by responsible manufacturers under close quality control may be considered in the front rank of materials for permanent construction.

But the codes reveal other things as well, facts that deserve the most careful attention from every far-sighted member of this growing industry. A study of the modern codes will reveal ways in which other codes may be improved, and will serve as a useful guide in rewriting the codes that are today inadequate to meet the situation.

Strength Requirements

Let us examine the tabulation of code requirements found on the next page. The first highly interesting facts are revealed in column two. Here we see that the American Concrete Institute, in its standard requirements, which were published after thorough discussion by engineers and blockmakers from all parts of the country and adopted by letter ballot of the entire organization, requires a minimum strength of 1200 pounds per square inch of gross area for heavy load-bearing block or tile, 700 pounds minimum compressive strength for ordinary load-bearing units, and 250 pounds for non-load-bearing units. The same recommendations call for 1500 pounds for concrete brick. The Hoover dwelling code agrees with the Institute on requiring 700 pounds minimum for hollow load-bearing units and 1500 pounds for concrete brick, as does the Hoover Masonry Wall Code applying to larger structures.

Going down the column to the requirements of the codes of actual cities we find, however, a lack of agreement with the above scientifically written suggested codes. Here we see Albany requiring 800 pounds for block, with no provisions for other concrete units, while Baltimore proposes to require only 700 pounds for hollow block and 1500 pounds for solid block, Birmingham requires block to reach a minimum compressive strength of 1000 pounds, Camden requires 750 pounds for hollow units and 1200 pounds for solid units, and Cincinnati requires an average minimum of 1500 pounds and an individual minimum of 1200 pounds on solid units, and average minimum of 1000 pounds and an individual minimum of 750 pounds on hollow units, and an average minimum of 1500 pounds and an individual minimum of 1200 pounds on concrete brick. On the other hand Cleveland, in its wartime code, requires 1200 pounds on the net section; while Columbus, in its more recent code, requires 1500 pounds for solid block and brick and 1000 pounds for hollow concrete block.

Dayton, in a code adopted the same year as the Cleveland code, does not specify compressive strengths as do the other codes, but allows a working stress of 150 pounds per square inch. Other discrepancies are to be observed in the same column. Notice that Denver requires that block reach a minimum strength of 700 pounds, while Detroit requires 1500 pounds on the net section. Erie, Pa., has adopted the American Concrete Institute requirements, while Jacksonville, Fla., has required 1000 pounds for block, Louisville specifies 1500 pounds on solid block but has no provision for hollow block. Memphis has the same requirements, Milwaukee requires 700 pounds for block and permits the use of eight-inch walls in garages, while New Orleans requires 1000 pounds, New York requires but 750 pounds, Omaha specifies 1000 pounds, Philadelphia calls for a like strength, Pittsburgh specifies 1500 pounds for solid units and 900 pounds for hollow block, Providence requires at least ten times the working stress, and Washington, D. C., calls for 700 pounds on block and 1500 pounds on brick.

Working Stresses

Working stresses, as shown in Column Three, likewise vary with the tabulated codes. The first working stress listed is that of the Hoover Masonry Wall Code. This authoritative document provides for an 80-pound stress for 700-pound block and a stress of 170 pounds for 1500-pound brick. A few comparisons with prevailing codes would be of real interest. Take, for instance, the Albany code. Here an 800-pound block is allowed a working

Building Code Regulations Affecting Concrete Block and Brick and Concrete Structural Tile

Name of Building Code and Year of Issue	Required Compressive Strength in Lbs. per Sq.In.		Allowable Absorption of Water (a) Block or tile (b) Brick	Maximum Percentage of Hollow Space	Minimum Web Thickness in Hollow Units	Minimum Wall Thickness of Hollow Units	Allowable Wall Height of Hollow Units	Classes of Buildings in Which Hollow Units Are Permitted	Permitted in Foundation Walls?	Hollow Units		
	Ultimate (a) Solid block (b) Hollow " (c) Brick	Working Stress (a) Solid block (b) Hollow " (c) Brick								Brand or Mark Required?	Date of Manufacture Required?	Permitted in Fire Limits?
1	2	3	4	5	6	7	8	9	10	11	12	13
††American Concrete Inst. (1924)	(b) 1200 & 700 250 (c) 1500	—	(a) 14 lbs. of water per cu. ft. of concrete in unit (b) 15 lbs. of water per cu. ft. of material	No restrictions	No restrictions	—	No restrictions Is governed by working stress	All classes	Yes	—	No	Yes
†† Hoover Dwelling Code (1923)*	(b) 700 (c) 1500	None stated. This code applies to dwellings only	(a) 10% of weight of unit (b) 10% for face brick and 12% for common.	No restriction Is governed by strength requirement	No restrictions	Minimum of 4" for interior bearing walls; 8" for exterior walls in both stories of 2-story dwellings.	—	This code applies to dwelling houses only	Yes	—	No	Yes
†† Hoover Masonry Wall Code (1925)**	(b) 700 (c) 1500	(b) 80 (c) 170	(a) 14 lbs. of water per cu. ft. of material. (b) 15 lbs. of water per cu. ft. of material. Absorption test waived under certain conditions.	No restrictions	No restrictions	Walls of hollow units same thickness as solid masonry with few minor exceptions	50 ft. above foundation wall.	All classes	Yes	—	No	Yes
Albany (1918)	(b) 800	(b) 110	(a) 10% of weight of unit.	33⅓	1½" for bearing block ⅝" for partition block.	Same as for brick walls. Minimum of 8"	3 stories or 42 ft.	All classes up to 3 stories.	Yes	Yes	No	Yes
†Baltimore (Proposed 1920)	(a) 1500 (b) 700	—	(a) 7% of weight of unit	35 to 45	At least ¼ of height of web	1" less than brick wall	4 stories	All classes up to 4 stories	Yes- If air spaces are filled with concrete	No	No	Yes
Birmingham (1912)	(b) 1000	(b) 110	(a) 15% of weight of unit	25	At least ¼ of height of web	8" minimum, as for brick walls.	No restrictions	All classes	Yes	Yes	Yes	Yes
†Camden (1922)	(a) 1200 (b) 750	(a) and (b) ⅛ of ultimate compressive strength if laid in portland cement mortar	(a) 12½ lbs. of water per cu. ft of concrete	No restrictions. Is governed by strength requirements	No restrictions	*** 8" for both stories of 2-story dwellings.	40 ft	All classes up to 40 ft. high.	Yes	Yes	No	Yes
††Cincinnati (1924) (Ordinance No. 80-1924)	(a) 1500-1200 (b) 1000- 750 (c) 1500-1200	(a) ⅙ of crushing strength of unit, but not over 250 lbs. (b) ⅛ of crushing strength of unit, but not over 250 lbs. (c) Same as (a).	(a) 14 lbs. of water per cu. ft. of concrete in the unit. (b) Same as (a). Absorption test not required in units not exposed to soil or weather	No restrictions. Is governed by strength requirements.	No restrictions	8" for both stories of 2-story dwellings Also 8" minimum for foundation walls not deeper than 4'-6" in 1-story and 2-story buildings.	40 ft. above first floor level	All classes wherever solid masonry is permitted	Yes	Yes	No	Yes
Cleveland (1917)	1200 on net section	200 on net section	(a) 6% of weight of unit	No restrictions	At least ¼ of height of web	Same as for brick walls	3 stories	All classes up to 3 stories	Yes	Yes	Yes	Yes
††Columbus (1923) (Ord. No. 33,743)	(a) 1500 (b) 1000 (c) 1500	(a) 300 (b) 200 (c) 300	(a) 10% of weight of unit (b) same as (a)	No restrictions. Is governed by strength requirements	No restrictions	8" for both stories of 2-story dwellings	No restrictions	All classes	Yes	Yes	No	Yes
†Dayton (1917)	—	(b) 150	—	50	Height of web not more than 4½ times thickness	Same as for brick walls	3 stories or 36 ft. for bearing walls.	All buildings of dwelling house class. Not for bearing walls in warehouse class.	Yes- In buildings of the dwelling house class.	No	Yes	Yes

1	2	3	4	5	6	7	8	9	10	11	12	13
†DENVER (1922)	(b) 700	(b) 60	—	—	No restrictions Is governed by ultimate strength	Same as for brick walls	40 ft	All classes up to 40 ft. high	Yes	No	No	Yes
†DETROIT (1922)	1500 on net section (?)	Not clear Probably 110	(a) 5% of weight of unit	35 to 45	No restrictions	Same as for brick walls. 8"= 1 brick length	4 stories	All classes up to 4 stories	Yes	Yes	No	Yes
† ERIE (1923)	Same as American Concrete Institute	—	(a) 14 lbs of water per cu.ft. of concrete in the unit	No restrictions. Is governed by strength requirement	No restrictions	Same as for brick walls	No restrictions	All classes	Yes	Yes	No	Yes
JACKSONVILLE FLA.- (1913)	(b) 1000	(b) 110	—	33⅓	¼ of height of web	Same as for brick walls	No restrictions. Is governed by unit working stress	All classes	Yes	No	No	Yes
†LOUISVILLE (1913)	(a) 1500	(a) 150	(a) 7% of weight of unit	50	2/9 of height of web	10% less than for brick walls	3 stories	All classes	Yes	Yes	Yes	Yes
†MEMPHIS (1912)	(a) 1500	(a) 150	(a) 15% of weight of unit	50	2/9 of height of web	10% less than for brick walls	No restrictions Is governed by unit working stress.	All classes	Yes	Yes	Yes	Yes
MILWAUKEE (1917)	(b) 700	(b) 60	(a) 8% of weight of unit.	35	No restrictions	12" minimum for warehouse class. 10" minimum for dwelling house class	60 ft	All classes up to 60 ft. high	Yes	Yes	Yes	Yes
NEW ORLEANS (1913)	(b) 1000	(b) 100	(a) 15% of weight of unit	45	1½" thick	Same as for brick walls.	Height limit same as for brick walls.	All classes	Yes	Yes	No	Yes
†NEW YORK (1922)	(b) 750	(a) 150 (b) 75	(a) 12% of weight of unit.	No restriction Is governed by strength of block	No restrictions	Same as for brick walls	40 ft	All classes up to 40 ft. high.	Yes-If air spaces are filled with concrete.	Yes	No	Yes
†† OMAHA (1923)	(b) 1000	(?)	(a) 10% of weight of block or tile.	No restrictions. Is governed by strength requirements.	¾" for concrete structural tile. Transverse webs in block 1". Longitudinal webs 1¼"	Same as for brick walls. (8", 12" etc.)	No restrictions Is governed by working stress.	All classes	Yes	No	No	Yes
PHILADELPHIA (1921)	(b) 1000	(b) 111 (8 tons per sq ft)	—	20 to 33	At least ¼ of height of web.	Same as for brick walls	6 stories	All classes up to 6 stories if approved by Building Inspection Department	(?)	Yes	No	Yes
†PITTSBURGH (1921)	(a) 1500 (b) 900	(a) 200 (b) 130	(a) 10% of weight of unit	No restrictions Is governed by strength requirements	No restrictions	Same as for brick walls	No restrictions. Is governed by unit working stress.	All classes	Yes	Yes	No	Yes
PROVIDENCE (1918)	(b) At least 10 times actual working stress	(b) 140	—	40% for buildings not over 3 stories. Less for higher buildings.	No restrictions. Is governed by ultimate strength	Same as for brick walls	6 stories	All classes	Yes	Yes	No	Yes
ROCHESTER (1911)	(b) 450	1/10 of ultimate strength	—	33⅓	No restrictions	Same as for brick walls	3 stories or 43 ft.	All classes	Yes	Yes	No	Yes
SALT LAKE CITY (1916)	—	1/10 of ultimate strength	(a) 10% of weight of block.	—	—	Same as for brick walls.	3 stories or 40 ft	All classes	?	Yes	No	Yes
WASHINGTON D.C. (1925)	(b) 700 (c) 1500	(b) 80 (c) 170	(a) 14 lbs. of water per cubic ft. of material (b) 15 lbs of water per cubic ft of material. Absorption test waived under certain Conditions	No Restrictions	No Restrictions	Walls of hollow units same as for Solid Masonry with a few minor exceptions	50 ft. above foundation wall Party walls of dwellings not over 40 feet	All Classes	Yes	—	No	Yes

†Requirements apply to concrete structural tile as well as to concrete block. ††Requirements apply to concrete brick as well as block and tile. *Published by the U. S. Department of Commerce in January, 1923, under the title of "Recommended Minimum Requirements for Small Dwelling Construction." **Published by U. S. Department of Commerce in 1925, under the title of "Recommended Minimum Requirements for Masonry Wall Construction." §The American Concrete Institute "Proposed Standard Specifications for Concrete Building Block and Concrete Building Tile" call for ultimate crushing strength, on gross area, of 1200 pounds per sq. in. for heavy load-bearing block or tile, 700 pounds for load-bearing, and 250 pounds for non-load-bearing block or tile. See also the American Concrete Institute "Proposed Standard Specifications for Concrete Brick." ***In Camden, N. J., the wall thickness of 1-story and 2-story dwellings of concrete block and tile may be 12-in. for the basement wall and 8-in. above the basement wall. In 3-story dwellings the basement wall must be 16-in. thick, the first story wall 12-in., and the upper two stories 8-in.

stress of 110 pounds. On the other hand, Birmingham requires a block to have a strength of 1000 pounds, but allows no greater working stress than does Albany with its weaker block. Camden, with its well-written code, requires that block be stronger than 750 pounds, and allows a working stress of one-eighth the ultimate compressive strength, provided that portland cement mortar is used in laying up the pier or wall.

Cincinnati allows one-sixth the compressive strength of solid units, with a maximum stress of 250 pounds, and one-eighth on block. Cleveland permits 200 pounds on the net section, while Columbus allows 300 pounds on solid units and 200 pounds on hollow units. Dayton, as pointed out before, allows but 150 pounds working stress on hollow units. Denver, with its 700-pound block, allows a working stress of only 60 pounds, and thus requires heavy and more expensive construction. Detroit apparently allows a working stress of 110 pounds on concrete block. Jacksonville permits 110 pounds on hollow units, Louisville and Memphis allow 150 pounds on solid units, Milwaukee permits 60 pounds, New Orleans 100, New York 150 for solid and 75 for hollow units, Philadelphia allows 111 pounds, Pittsburgh permits 200 pounds for solid and 130 for hollow units, Providence permits 140 pounds for hollow block, Rochester and Salt Lake City both specify one-tenth of the ultimate strength, and Washington allows 80 pounds for block and 170 pounds for brick.

Absorption

Further differences of opinion are seemingly registered in the column devoted to permissible absorption. This item is variously specified in terms of a percentage of the weight of the unit and as so many pounds of water per cubic foot of material. More important, however, is the fact that permissible absorptions cover quite a range. The American Concrete Institute suggests an absorption limit of 14 pounds of water per cubic foot of concrete for block or tile units, and 15 pounds of water per cubic foot for brick. The Hoover Dwelling Code puts this at ten per cent of the weight of the unit for block and tile and for face brick and 12 per cent for common brick. The Hoover Masonry Code, published at a later date, sets the limits at 14 pounds of water for block and 15 pounds for brick, and provides for waiving the absorption test under certain conditions. Among the regular codes, the absorption limits run between 5 and 15 per cent, or between 12½ and 15 pounds of water per cubic foot of material, depending upon the city. Washington, D. C., has apparently adopted the Hoover Masonry Wall Code in this and other respects.

Permitted Hollow Space

As to the maximum percentage of hollow space, and the minimum web thickness, there is an equal, or greater, lack of agreement. No restrictions are to be found in the three standard codes heading the tabulation, nor do nine cities, whose codes have been examined, restrict the maximum hollow space. Twelve cities do not restrict the thickness of webs in hollow units. Albany, however, sees fit to set the maximum percentage of hollow space at 33 1/3 per cent, while other cities set this at 20, 25, 33, 35, 45, or 50 per cent respectively, while web thickness is expressed in terms of fractions of height or in terms of inches, and ranges in each classification between ¾-inch to 1½ inches, or is expressed as 2/9 of web height by two cities, ¼ web height by five cities, and one city specifies that the web height shall be not more than 4½ times the web thickness.

Another interesting portion of the table, consisting of columns 7, 8, 9, and 10, deals with the actual use of the units in wall construction. Here again we see the record of a lot of interesting history and a comparison of the attitude of the various building officials. Eighteen of the codes, and the two Hoover codes, say that concrete masonry may be laid up in a wall on a par with brick construction. Three codes, notably those of Baltimore (proposed code), Louisville, and Memphis go still further and permit a reduction in thickness in favor of the concrete masonry. The first says that the wall may be one inch thinner than the corresponding brick wall, while the other two permit a ten per cent reduction in thickness. The Camden code and the Columbus code permit eight-inch walls, while Milwaukee sets the minimum at 10 inches. The Cincinnati code agrees with the Camden and Columbus codes, permitting an eight-inch wall for two-story residences. Birmingham and Albany do likewise, putting the material in the same class as clay brick.

The column devoted to allowable wall heights is also interesting. Here we see that seven codes make no restrictions, interesting themselves only in the working stresses, while New Orleans simply says that the limit will be the same as for clay brick walls, while the other codes all set a definite limit, either in terms of stories or in feet. The Hoover Masonry Wall Code suggests that the limit be placed at 50 feet above the foundation wall, while other opinions place this limit at three stories, 42 feet, four stories, 40 feet, 36 feet, 60 feet, and six stories, respectively. The next column seems to be quite unanimous in stating that concrete masonry should be permitted for use in bearing walls in all types of buildings up to the height limits set by the code. Thus, in codes such as that of Pittsburgh, there is apparently no reason why tall buildings cannot be built of concrete masonry if the working stresses are not exceeded. This certainly would fix the limit at the mark set by economic considerations rather than at some arbitrary point set by law. It is of interest, too, to note column 10. Here all but two codes permit the use of concrete units in foundation walls, while three of the others require the air cells to be filled with concrete.

Branding of Block

The remaining three columns, also, show an interesting trend. Here we see that eighteen codes require the hollow units to be branded with the registered mark of the manufacturer, while six require the date of manufacture to be stamped on the unit, and every code listed permits the use of concrete masonry construction within the fire limits of the community.

There are five tests that the block manufacturer may apply to a building code in order to see whether or not it is scientifically and correctly written. First, the code must be so devised that the required compressive strength, absorption, and allowable unit stresses are such that a high standard of production may be maintained at a cost that will permit fair competition with other fireproof construction materials. Second, the code must provide for the use of units in all types of construction on a plane of equality with other permanent materials. Third, the code must be so written, in its entirety that no hidden joker will nullify apparently favorable provisions. Fourth, the code must be so written that a high type of construction is insisted upon, in order that the good unit will give a good account of itself under fire and wind exposure. Fifth, the code must place a premium on proven worth and automatically penalize the producer who deliberately turns out a poorer product. These are all fundamental requirements of a good masonry code, and unless the requirements are carefully met the industry will continue to be retarded in its deserved growth.

Rewriting Codes

There are many codes today that do not meet the needs of the industry. They were written in the days when block was not accepted universally as one of the most reliable of building materials. Sporadic attempts to remedy the situation since the original code was adopted have often resulted in almost meaningless and ineffective amendments. It would be well worth while, in these communities, for the subject of a new code to be brought up, and an experienced man appointed for the purpose of entirely rewriting the code and bringing it up to date. The tabulation presented herewith mentions a few scientifically written codes that would be of service in this work. Codes such as that provided by the American Concrete Institute, the code adopted by Camden, and by several other cities are well worth attention.

There are several important points to be remembered in deciding upon the requirements of the codes. The block themselves must be amply strong to stand the rough treatment incident to construction, the action of the weather, and the treatment to be encountered in the average fire or high wind. The masonry wall, however, is no stronger than its mortar. The recent Florida disaster and other similar events prove conclusively that portland cement mortar is a requisite to good construction. The mortar must be of the right sort, since a weak mortar will fail and permit the destruction of a wall in spite of the good strong units that may have been used. The ideal situation is to use a mortar that will develop the full strength of the block. This is not difficult. In fact it is attained every day by the good mason. Thus, there can be no bond failures in concrete masonry, but the effect will be that of a monolithic wall. The concrete masonry destroyed by the Florida wind was masonry in which mortar was used, and the failures were bond failures. The multitude of well constructed concrete masonry dwellings in Coral Gables, in the very center of the devastated area, came through unscathed.

Restrained Areas

But it is not sufficient to lay up good block in good mortar. Concrete at the best cannot stand any great tensile stresses. It is a material designed to act in compression. It is logical, therefore, to provide reinforced concrete pilasters and girders in larger concrete masonry walls. These are easily cast in place at a nominal cost. The Florida storm again demonstrated the necessity for this type of construction. It is important, however, that this framing be carried up the full wall height, since unrestrained parapet walls were found to fail and lead to damage to the rest of the structure. Pilasters erected at frequent intervals will so brace the structure that the walls cannot be overturned or pushed outward. It is important, too, that the roof structure be well bolted to the wall structure. It might, too, be well to investigate the advisability of permitting the use of interlocking tile without mortar joints when the design of the tile permits, and the wall areas are restrained as described.

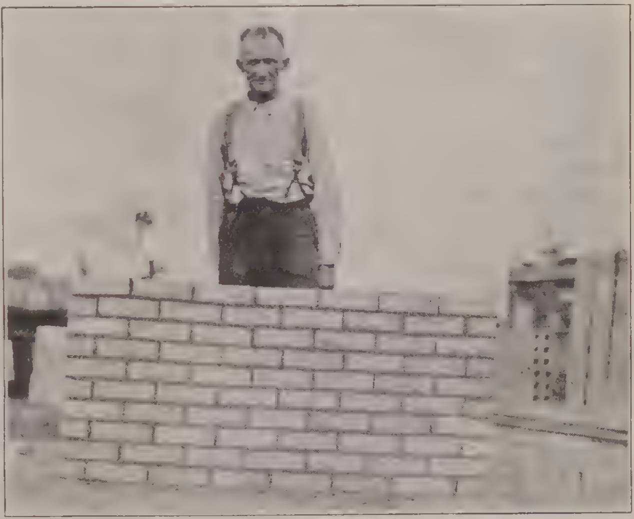
Good block, plus good construction, make for a concrete masonry structure that will be as good as any. The mission of the code must be the assurance of this good production and good construction, for the sake of the property owner himself and the bank that finances his construction, and above all for the good of the industry. For when concrete masonry construction has been slighted and trouble develops, the entire industry will be blamed. The public remembers faults and forgets merits. Codes must be written and enforced accordingly.

Duntile Men Hold Rally in Michigan

Plenty of action was shown at the gathering of Duntile men of eight states when they met in Benton Harbor, Michigan, a short time ago. One feature of the event was a competition between two experienced masons; one laying a brick wall and the other a Duntile wall. Those present saw a Duntile wall 30 inches high, 60 inches long, and 6 inches thick erected during the time it took the other man to lay a brick wall 28 inches high, 58 inches long, and 4 inches thick. Not only did the experienced men present agree that the concrete wall was laid far better than the clay affair, but measurements showed that the Duntile wall had a cubage about three times that of the clay brick wall. The pictures presented on this page demonstrate the matter in an interesting way.

Here is the Duntile wall that was laid up while the bricklayer was laying up the smaller wall shown in the other illustration

Another event took place in the local Duntile plant of the National Concrete Corporation. Here two teams competed for production, each team taking a machine. The event was a draw, since both the Benton Harbor team and the Holland crew succeeded in producing 122 tile in 21 minutes and 50 seconds. Three men easily showed that it was possible to maintain an hourly rate of 360 tile.



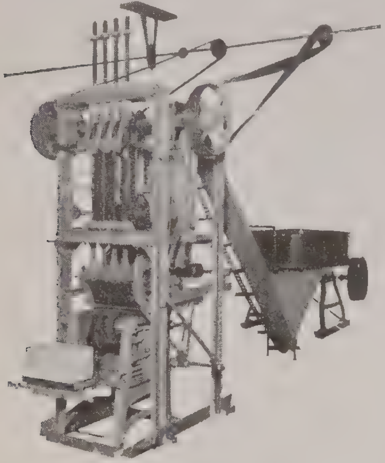
This four-inch brick wall shows rather sloppy and rushed workmanship, yet it went up much slower than the concrete masonry wall erected by the other man. Both were experienced workmen

Another interesting demonstration consisted in loading a truck with Duntile by hand, and then dumping the contents of the truck to the ground without using any more care than is exercised in handling aggregates. After this rough treatment at least 97 per cent of the tile were found to be in perfect condition.

New Equipment

New Block Machine for Batch or Continuous Mixer

Products plant operators have become interested in the excellence of the new "Blue Ribbon" block machine placed on the market by the Abram Cement Tool Company, Detroit, Michigan.



One of the features of the machine is the elimination of springs from the power tamper. Pure rubber snubbers, in place of springs, insure less vibration, a greater blow to the material, and greater rebound to the tamper bars. Malleable iron tamper feet are used instead of grey iron. The steel double safety lift lugs have a safety catch, eliminating the necessity of attaining full running speed before the stop levers function.

A simply constructed channel steel drag elevator, designed to be entirely self-cleaning in operation, is guaranteed not to clog or stall.

Other details of construction are an elevator boot so designed that either a batch or continuous mixer may be used, or it may be made to discharge a portion of the mixed concrete on the floor. A large reserve capacity in the concrete magazine is sufficient for about 20 8x8x16 blocks.

The construction of the machine is such that it may be purchased in a unit complete or in sections consisting of a down face end stripper block machine, power tamper, self-feeder and elevator.

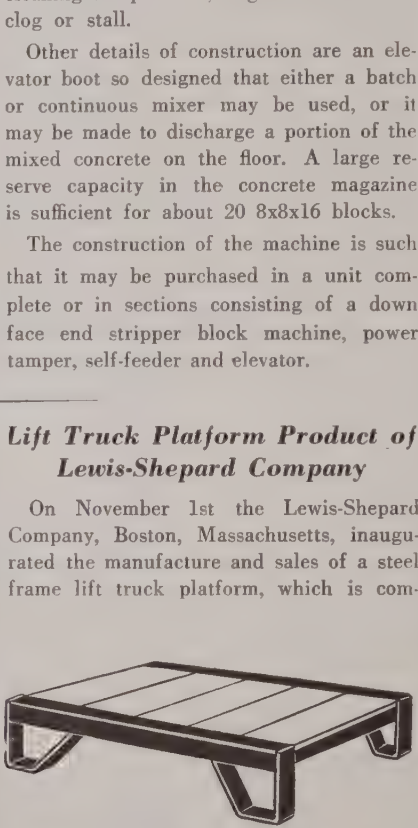
Effective Vibrating Screen Heralded by Link-Belt

Marked by simplicity of construction and possessing adaptability to almost any fine screening condition, a new ball bearing vibrating screen has just been announced by the Link-Belt Company, of Philadelphia, Chicago and Indianapolis. This screen is a mechanically operated device consisting of one moving part which rotates in large, oversize ball bearings. The shaft is driven at suitable speed from any common source of power, is thrown out of balance by adjustable counterweights and imparts vibrations to the screen box on which it is mounted. These vibrations are transmitted to the screen cloth secured, under tension, in the box.

A feed hopper attached to the receiving end of the screen box vibrates with it, controls the feed, and uniformly spreads the material over the screening surface. For screening materials containing small particles, the vibrating feed hopper is fitted with a counterweighted swinging feed gate. This combination makes it easy to receive a non-uniform feed, and spreads the material over the width of screen cloth at exactly the right speed, also adding about two feet to the effective length of the screen and obviating the use of mechanical distributors.

Lift Truck Platform Product of Lewis-Shepard Company

On November 1st the Lewis-Shepard Company, Boston, Massachusetts, inaugurated the manufacture and sales of a steel frame lift truck platform, which is completely steel bound. All boards are protected by steel binding. The steel frame is a unit in itself and does not depend upon the clamping of the steel frame and feet to the wood top for strength or rigidity. The entire metal structure is arc-welded into the equivalent of one solid piece.



The clearance from the underside of the platform to the floor is the same on both sides and both ends, permitting a lift truck to be backed in under either side or either end. The top of the platform is flat. The steel does not extend above the boards nor the boards above the steel.

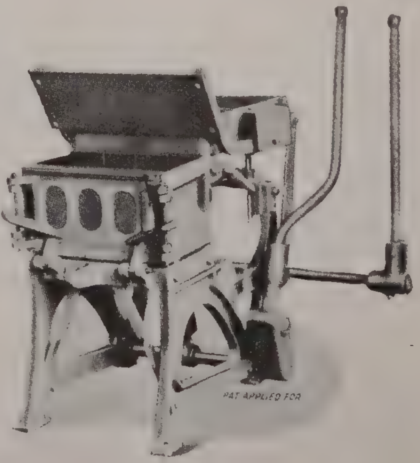
Colloidal Admixture Perfected for Concrete

A new admixture that is designed to give greater workability, make drier consistencies possible, and speed up the work, with the attendant advantages of these benefits, has just come on the market. This material comes in a powdered form and when mixed with water in the mixer it forms a jelly-like, or colloidal, substance that effectively lubricates the mix. It will take up ten times its own volume of water, and later hardens with the concrete itself. The material is principally silica, alumina, and various alkaline earths, and is slightly alkaline in reaction. Two pounds are used for each sack of cement. Interesting results have been reported from laboratory tests and field tests that have been made with the material. This admixture is known as Colloy and is manufactured by the Colloy Production Co., 4030 Chouteau Avenue, St. Louis, Mo.

Ideal Marketing New 3-Core Block Machine

The new Ideal Machinery Company three-core, face-down block machine allows from 33⅓% to 40% air space and can be used either in hand or power equipment. It is supplied also for use with either wood or iron pallets. When desired for use with power, the machine is supplied with self-contained material hopper and finisher.

The machine will make any standard blocks 8″ high, 8″ wide and 4″, 8″, 12″ and 16″ long with plain and standard or open ends.



With the Manufacturers

INDUSTRIAL LITERATURE

"Red Line" Catalog

The complete *"Red Line"* products of the *Kent Machine Company*, Kent, Ohio, are gathered into one catalog, newly issued. The *"Red Line"* includes continuous mixers, step molding machines, lift trucks, pallets and the remainder of a complete concrete products outfit and material handling system.

New Osgood Bulletin

The new *Bulletin 2620* of the *Osgood Company*, Marion, Ohio, illustrates to advantage the single massive steel cast foundation, the rugged continuous tread truck and other details of construction on the Osgood gas and electric 1 cu. yd. shovel. It covers also its use as a crane, and dragline excavator, as well as a separate back hoe attachment for various types of trench work.

Booklet on Admixture

An interesting leaflet has just been received from *The American Fluresit Company*, 27 East Water Street, Cincinnati, Ohio, describing their new admixture known as *Fluresit*. This material is just being introduced to this country after proving successful abroad after a number of years' use. Its properties are said to be such that it densifies and waterproofs concrete and adds about 40 per cent to the tensile and compressive strength of the concrete in which it is used. The leaflet contains test reports from the laboratory of the H. C. Nutting Company, who have investigated the merits of the material.

Lehigh Issues Farm Book

Educating the farmer to employ the cleanliness of concrete dairy barns and floors, fruit and vegetable storage, well covers and cisterns, is the purpose of the *Lehigh Portland Cement Company's* farm book, newly issued.

"The Lehigh Farm Book" contains 48 pages of detailed and thorough instructions, from the platform for the handmixing, through the leveling of barn floors, to suggestions for a number of uses for concrete about the farmhouse. This is a completely illustrated handbook, making a good concrete propangandist, and should reach the hands of many farmers.

Government Paper on Beams

Shear Tests of Reinforced Concrete Beams, by W. A. Slater, A. R. Lord, and Roy R. Zipprodt, is the title of Technologic Paper No. 314 of the U. S. Bureau of Standards. This authoritative paper gives the results of tests carried out on reinforced concrete beams in the establishment of a basis for design of concrete ships during the World war. Cracks, the paper shows, generally began to appear in the test beams at shearing stresses of 100 to 300 pounds per square inch. The tensile stress in the web and the shearing strength of the beam were generally dependent upon the compressive strength of the concrete in the beam and directly dependent upon the amount of web reinforcement. Comparative merits of various methods of reinforcing are discussed in the paper. Copies of this document may be secured upon application to the superintendent of documents, Government Printing Office, Washington, D. C., at a nominal price.

Booklet on Stone-Tile

"What Is Stone-Tile?" asks the booklet published by the *National Stonetile Corporation*, San Francisco, California, and then proceeds to solve the mystery. The contents of the 15 pages embrace the sources of the material, its use in different types of construction, its adaptability and flexibility, the designing and ordering, construction details, the laying of *Stone-Tile*, as well as specifications, tests, and the manufacture.

Winter Construction Help

The winter construction booklet issued by the *Atlas Lumnite Cement Company*, New York City, pictures and describes successful performances in cold weather construction featuring the use of *Lumnite* cement, in two particularly outstanding cases. Under the heading "Suggestions for Using Lumnite Cement" appear paragraphs on proportioning, mixing water, proper curing and bonding. Copies of the booklet may be secured from the firm.

NOTES FROM THE MANUFACTURERS

Form Manufacturer Expanding

The Heltzel Steel Form & Iron Company, Warren, Ohio, advise that the demand for their equipment during 1926 has necessitated expansion for the increased business. A new addition providing 42,000 additional square feet to be devoted to the manufacture of steel bins, road forms, etc., is well under way.

The new addition is of the double bay type, equipped with two new 10-ton cranes and other modern machinery necessary for the fabrication of equipment.

Clamp Firm Moves

The factory and offices of the *Symons Clamp and Manufacturing Company* are now located at 4249 Diversey Avenue, Chicago.

Appoint Coast Manager

The *Williams Form Clamp Company*, Chicago, has appointed *W. J. Burke* manager of their new Pacific Coast branch, 200 Davis Street, San Francisco, California, covering the states of California, Washington, Oregon, Colorado, Arizona and Idaho.

New Pollak Steel Co. Offices

The Pollak Steel Company, Cincinnati, Ohio, has opened sales and engineering offices in the Penobscot Building at Detroit. *Mr. B. G. Yalman*, district sales representative and *Mr. W. R. Klinkicht*, metallurgist, have been placed in charge.

Agents for Labor-Savers

The *Fischer and Hayes Rope and Steel Company*, 816 West Erie Street, Chicago, have been appointed exclusive sales agents in the United States for *Anchor* shore clamps, *Kardong* column clamps and *Nelson* spreader ties. They are also sales representatives for the *Chicago Form Clamp Company* and handle all of its products.

Milwaukee Clamp Distributors

The *Cunningham-Ortmayer Company*, 14 Grand Avenue, Milwaukee, Wisconsin, have been appointed Wisconsin distributors for the *Williams Form Clamp Company*, Chicago, Illinois.

With the Manufacturers

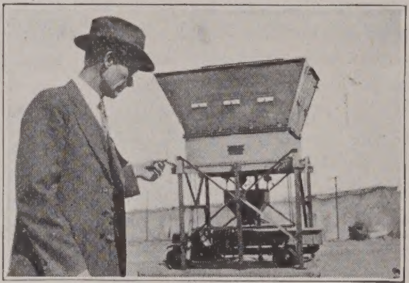
Second Annual San Francisco Road Show Exhibits Many Devices Interesting to the Highway Builder—Demonstrations Staged—Some of the Exhibitors

The building of a twenty-foot stretch of concrete highway, from rough grading to the surface finishing was one of the interesting demonstrations exhibited at the second annual All-Western Road Show held in San Francisco, October 7 to 15.

This exhibit was staged by the Edward R. Bacon Company, using equipment for which it is the western representative. A Byers Bearcat skimmer did the rough grading and loaded a truck. Following the Bearcat, a 60-Caterpillar tractor was shown drawing a Baker-Maney scraper. Then came a Jaeger concrete mixer and placing plant which built a box culvert, beyond which was Ventura scarifier drawn by a 30-Caterpillar tractor, followed by an Adams Leaning Wheel grader drawn by a 60-Caterpillar. A Johnson scarifier drawn by a two-ton Caterpillar did the light scarifying. An Acme roller compacted the subgrade and furnished power for the Carr Subgrader, bringing the subgrade to exact template. A Burch spreader distributed the rock on a 10-foot strip. A 27-E Timken-equipped Multifoote paver made the concrete road, following closely the California Highway Commission's specifications.

Of interest also was a piece of concrete pavement bearing the date of May 2, 1871, which had been uprooted by a Barber-Greene ditcher.

The following list gives an idea of the variety and choice of equipment shown:



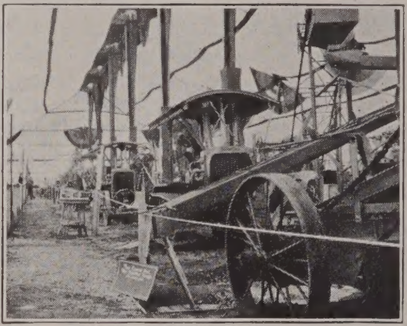
Working model of small concrete proportioning plant

Koehring Company, Milwaukee, Wis., exhibited gasoline shovels, three types of pavers; mixers and a subgrade planer.

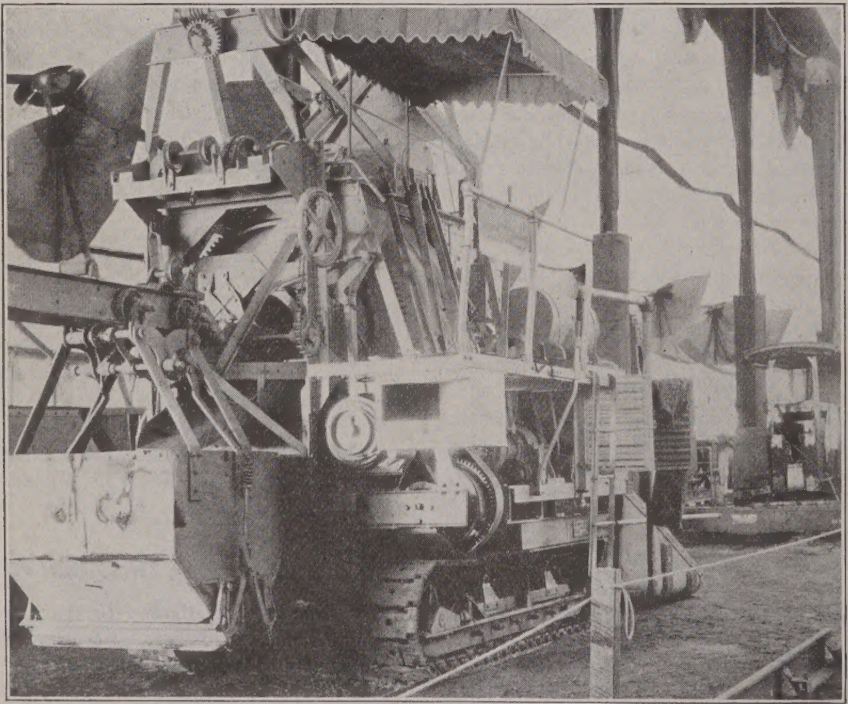
C. H. & E. Manufacturing Company, Milwaukee, Wis., Mud Hen portable diaphragm power pump, saw rig, and hoist.

Blaw-Knox Company, Pittsburgh, Pa., exhibited steel road forms, curb and gutter forms, volume batcher, inundation system, and bins.

The Knickerbocker Company, Jackson, Mich., showed a new model 5-S concrete and plaster mixer.



Displaying Caterpillar tractor and box culvert



Multifoote paver exhibit

George Haiss Manufacturing Co., Inc., New York, featured a creeper path digging truck loader equipped with swivel spout and clean-up scraper.

Ransome Concrete Machinery Co., Dunellen, N. J.: Ransome extra heavy 27-E paving mixer and smaller building mixers.

National Steel Fabric Co., Pittsburgh, Pa., exhibited various types of road fabric, featuring a new type of mesh reinforcement designed for giving increased support at the edges of pavements.

The Pacific Silicate Company was installed in a miniature booth featuring Dow Flake.

McKiernan-Terry Drill Company, New York City, featured two operating models, a land pile driver and submarine pile driver, as well as several large size hammers.

The Portland Cement Association featured concrete roads and structures by samples, photographs and moving pictures. Arthur P. Denton, district engineer of the San Francisco office, had charge.

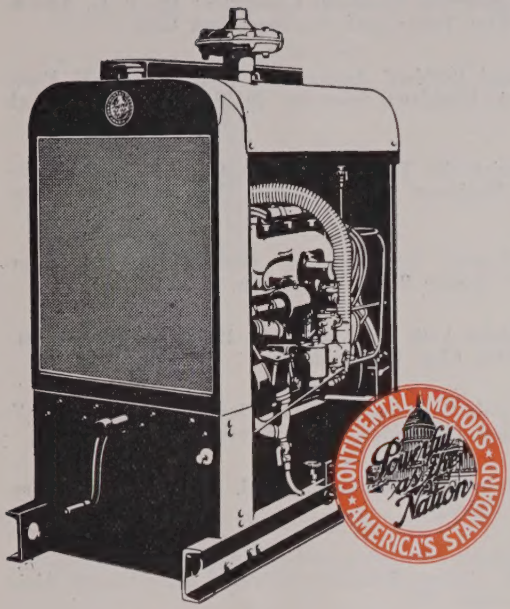
The C. S. Johnson Co., Champaign, Illinois, featured batch proportioning hoppers.

A. W. French & Co., Chicago, Illinois, showed the Ord concrete finisher.

The Easton Car & Construction Co., Easton, Pa., featured Won-Way, Granby and Phoenix cars.

Mead-Morrison Manufacturing Co., East Boston, Mass., showed clamshell buckets.

Power for a ~ thousand uses



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Where industry functions, power has a place.

Wherever gasoline power is used, Continental Motors are outstanding for dependability, economy and proper design.

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Offices: Detroit, Mich., U. S. A. *Factories:* Detroit and Muskegon
The Largest Exclusive Motor Manufacturer in the World

Continental Motors

Mixer Musings

Reported by "Joe"—The Mixer Boss.

Handle With Care!

Winter's the time for tarps, for salamanders, for anti-freeze, an' for hot coffee. It used to be the time for plenty of alki in every man's radiator, too, but reformers an' safety-first sharks stopped that way of pushin' the job through on time. But the tarps an' salamanders are still with us, an' you can't do without them.

But heatin' the job and burnin' it down're two different things. That's what one fellow found out not so long ago when he found himself with a winter job on his hands. He'd heard that plenty of tarps an' salamanders would do the trick, so he ordered a bunch of both from the guy who'd sold him the rest of his equipment. He rigged up the tarps good an' tight and stoked up the heaters, an' then chased the gang home for the night. Now, he'd not remembered that tarps aren't like a concrete wall, an' that they can burn, so he wasn't careful where he put those fire pots. That night was a windy one. In fact, it was a rip-snorter!

Along toward midnight, when the night watchman began to get more interested in warming himself by the stove than in climbing ladders, a sudden gust of wind worked a corner of a tarp loose and flipped that corner into the bed of fire in a salamander. First the tarps all caught on that bay, then the blaze spread to the next bay, and about that time the forms began to catch, just as the watchman woke up to what was happenin'. He ran out an' turned in the alarm, which was about all he could do by then.

At any rate, the forms an' shoring burned out from under a green slab, an' it went, an' the shores an' forms went from under the lower slab, an' it went, the shock took the rest of that bay an' another one with it, before the fire lads could do their stuff. 'Twas a nice mess, an' cost the contractor a lot of jack to make good. He charged it up as "Edication."

Heard the other day that "Spec" was scootin' around tryin' to organize somethin' for the Products Convention. Wonder what'll happen this February when "Spec" pulls his surprise?

Everybody's gettin' excited about this here Queen, said Pat to me the other day, but for myself, says Pat, I prefer Aces! Just then Jake, who was settin' in on the game, found a hundred of 'em in his fist. It was a cent a point game, too.

The concretor is coming to the point where he'll have to be a good salesman, or else hire one. Now that jobs are not so easy to get, the contractor'll have to promote jobs for himself, or sell the idea of accepting his prices instead of the other fellow's. With so many in the field, and with no great increases in construction in sight, it'll be a case of sell or get out. That applies to products men as well.

How many of you fellows like my stuff? Drop me a line an 'tell me to keep it up or to go to 'ell. It's a poor broadcaster that doesn't get the cards once in a while. I've heard from some, but how do YOU feel?

Joe, The Mixer Boss.

Organizations

American Concrete Institute; Harvey Whipple, Secretary, 2970 West Grand Blvd., Detroit.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 W. Grand Ave., Chicago.

American Construction Council; Dwight L. Hoopingarner, Executive, 28 W. 44th St., New York City.

American Engineering Standards Committee; Dr. P. G. Agnew, Secretary, 29 West Thirty-ninth St., New York City.

American Road Builders' Association; Wm. H. Connell, President, Miss E. A. Birchland, Secretary, 29 W. 39th St., New York City.

American Society for Testing Materials, C. L. Warwick, Secretary-Treasurer, Engineers' Club Building, 1315 Spruce St., Philadelphia, Pa.

Associated General Contractors of America: D. H. Sawyer Secretary, 1150 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 West Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference: H. E. Plummer, President, J. F. Downey, City Hall, Cambridge, Mass., Secretary.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, Tribune Tower, Chicago.

Concrete Products Association; John E. Powers, President, Sterling, Ill.; D. R. Collins, Secretary, 47th and State Streets Alois postoffice, Milwaukee, Wis.

Concrete Products Association of Greater Boston; Glenn T. Hoyt, Secretary, 80 Whitman Ave., Melrose, Massachusetts.

Iowa Concrete Products Association: H. E. Meier, President; R. L. Gavin, Secretary-Treasurer, 405 Hubbell Bldg., Des Moines, Iowa.

National Association of Building Trades Employers; A. E. Coleman, President, 37th St. & Stewart Ave., Chicago. A. W. Dickson, Executive Secretary, 214 Electric Bldg., Cleveland, Ohio.

National Association of Builders' Exchanges; William F. Chew, Baltimore, President; Earl F. Stokes, Secretary, 15 East Fayette St., Baltimore, Md.

National Crushed Stone Association; J. R. Boyd, Secretary, 751 Earle Building, Washington, D. C.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East Twenty-second St., New York City.

The National Lime Association; Burton A. Ford, Secretary, 918 G Street, N. W., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 933 Leader-News Building, Cleveland, Ohio.

National Sand and Gravel Association, V. P. Ahearn, Executive Secretary, 432 Munsey Bldg., Washington, D. C.

Nebraska Concrete Products Association; A. V. Anderson, President, Reimers-Kaufman Co., Lincoln, Neb.; E. L. Bateman, Acting Secretary, Bethany, Neb. Annual Convention, Hotel Rome, Omaha, January 27, 28, 1927.

Ohio Concrete Products Association; G. M. Friel, Secretary-Treasurer, 2284 North High St., Columbus, Ohio.

Portland Cement Association; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Wisconsin Concrete Products Association; A. P. Kuranz. Secretary-Treasurer, 425 E. Water St., Milwaukee.